JUNE, 1941

THE Petroleum Engineer

VOL. XII—NO. 9

THE PETROLEUM ENGINEER PUBLISHING CO. . . . Phone: Central-4571 . . . Seventh Floor Allen Building . . . DALLAS, TEXAS
Clarence Morris, President, 1929-40

A Magazine of Methods for Operating Men

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MEMBER A. B. C.—A. B. P. (The Articles in *The Petroleum Engineer* are indexed in the *Industrial Arts Index*, New York, N. Y.)

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CASING SERVICE
Remember that your casing cost is measured in terms of service, and not in the price alone.
Into Youngstown casing is built the strength and quality to insure trouble-free running in and satisfactory performance through a long lifetime. Every length of pipe is built to exact specifications and closely inspected at every step, with a final strenuous hydrostatic test -- your assurance of a margin of safety adequate to meet severe service requirements.
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On this huge Youngstown machine, round billets for seamless tubular goods are being "peeled" to insure that the finished pipe is free of surface defects.
2-29D
YOUNGSTOWN

The Course of Oil

by K. C. SCLATER

Mr. Ickes and Conservation

Appointment of Secretary Ickes as Coördinator of the petroleum industry is a reminder of the importance of petroleum in the present National emergency.

It is certain that Mr. Ickes will hasten the enactment of appropriate conservation legislation in all oil-producing states. Mr. Ickes has already requested action making the proration law in Texas permanent. At this writing, the Texas State Legislature has under consideration the enactment of a permanent oil proration law. Texas, of all states, has had ample demonstration of the benefits of proration. The East Texas field today, had it not been for proration, would not have known the benefits of a natural water drive. It would have been a field of small pumping wells, whose lifting costs would be many times higher than prevailing lifting costs in that field. A permanent proration law in Texas is justified.

In the case of the State of Illinois, Mr. Ickes is reported to favor a conservation law that will prevent waste, but he does not see the necessity for including curtailment, or proration, to balance supply and demand. He has stated that the oil production of Illinois can be used to great advantage at this time when there will be a heavy demand on transportation facilities because the fields of Illinois are in the heart of a great industrial and consuming center. With respect to transportation facilities, Mr. Ickes' stand regarding Illinois is quite justifiable; but unless Mr. Ickes has in mind Illinois' position only in this emergency period, the inconsistency of his wishes with regard to proration in Illinois and that in Texas is not understandable.

Utilizing Sour Gas

Sour gas in South Arkansas will soon become an important source of industrial power in that State. It has been announced by the Lion Oil Refining Company of El Dorado, Arkansas, that it has embarked on a pioneer project that will include the construction of the first large capacity hydrogen sulphide removal plant in that section of the country. The plant will be constructed in the Magnolia field, southwest of El Dorado, and will have a capacity up to 15,000,000 cubic feet of gas daily.

This is an important conservation measure. Sour gas heretofore unfit for use because of its sulphide content, will be made available as a fuel in a refinery and other industrial plants. The availability of this gas for industrial use will release a corresponding volume of sweet gas for repressuring purposes in the Shuler field, which is the site of one of the State's outstanding conservation projects.

Arkansas is one of the states leading in oil and gas conservation practice. The utilization of sour gas resources in this instance is a demonstration of the alertness of Arkansas operators to the benefits of adopting conservation measures wherever practicable.

British Oil Industry's Loss

In the death of Lord Cadman in London, England, last month, the British petroleum industry has suffered a great loss, particularly at this critical time in that country and its far-flung petroleum empire. He was chairman of the board of the Anglo-Iranian Oil Company, Ltd., and also of the Iraq Petroleum Company, Ltd., two important large oil companies whose fields are in the Near East and now near the scene of hostilities.

Lord Cadman was first and foremost a technologist of unusual talents. Combined with his technological and business acumen, he also possessed rare ability as an administrator. Under his leadership the Anglo-Iranian Company pioneered and put into practice many scientific methods of oilfield development and exploitation on a scale not practiced anywhere else in the world. Throughout his career, he remained a staunch advocate of scientific methods of oil production, one phase of pioneering in which, as a guiding influence, he will be missed by the entire British oil industry. He has left behind him an impressive record of achievement in furthering sound methods of petroleum development.

Wildcatting Essential

Much has been made of the report, based on state by state estimates, that "without any excessive drilling program, production could be increased by 30 percent and maintained at this figure for at least two years without any major new discoveries." Although the industry can increase the rate of production over night—whether by thirty percent without harm to existing reserves is problematical—it is well to remember that reserves are, or should be, based on the assumption that the oil will be produced at the optimum rate from the reservoir. It is a mistake to assume that wells can be opened up indiscriminately and allowed to produce at any desired rate, an idea that seems to prevail outside the industry, yes, and even in some quarters within the industry.

Although the rate of production can be increased over night, the discovery of new fields is still subject to the element of time—and also gamble. We are passing through a critical period in world history in which petroleum is playing a vital part. In the face of changing world conditions in which National emergencies and exigencies are likely to arise, it should be emphasized that, although a bottle-neck in development, producing, or refining operations is quite unlikely, the need for carrying on normal exploration and wildcatting operations is now more imperative than ever to assure that ample reserves of oil in the United States will be maintained in the face of a possible period of accelerated consumption.

Measure the VALUE of "Hercules" (Red Strand) Wire Rope by what it will do

REG. U.S. PAT. OFF.

RESULTS are what count — now more than ever. In order to speed up production, and still maintain a reasonable margin of profit, it is of utmost importance to use materials and equipment of proven dependability.... For over 55 years "HERCULES" (Red-Strand) Wire Rope has been demonstrating its stamina and trustworthiness. Its record of *consistent* performance — day after day, and month after month — has made and held a host of loyal friends. Such performance is never a matter of chance, but the result of sound fundamental principles, extensive research, experienced organization, and efficient manufacturing facilities.

Why not measure the ultimate value of "HERCULES"(Red-Strand) Wire Rope by the accurate yardstick of performance? Give it a chance to prove just what it can do. You will quickly discover that its long life makes for more continuous production and lower operating cost.

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Highlights IN OILDOM

Ickes Named Petroleum Co-ordinator

President Roosevelt, on the last day of May, appointed Secretary of Interior Harold L. Ickes federal coördinator of the oil industry for the National Defense Committee. The appointment empowers Ickes to regulate the producing, refining, development, and transportation branches of the industry; to prevent unnecessary drilling; to determine and prevent unnecessary activities. Ickes also is authorized to appoint, subject to the president's approval, deputy coördinators, and already has made one such appointment, Ralph K. Davies of San Francisco, vice-president of the Standard Oil Company of California.

President Roosevelt's letter to Secretary Ickes follows:

"In order to provide the desired coördination, I am hereby designating you as petroleum coördinator for national defense. In that capacity it will be your function and responsibility as my representative:

"First, to obtain currently from the states and their agencies, from the petroleum and allied industries, from the offices and agencies of your department, and from other appropriate federal departments and agencies information as to (a) the military and civilian needs for petroleum and petroleum products, (b) the factors affecting the continuous, ready availability of petroleum and petroleum products for those needs, and (c) any action proposed which will affect such availability of petroleum and petroleum products.

"Second, to make specific recommendations to any appropriate department, corporation, or other agency of the federal government, particularly the office of Production Management of the office of Price Administration and Civilian Supply, to the appropriate agency representing any state or any combination of states, and to any appropriate industry or part thereof, as to action which is necessary or desirable, on the basis of your determinations, to insure the maintenance of a ready and adequate supply of petroleum and petroleum products."

Ickes Wants Conservation Law for Illinois

In his capacity as petroleum coördinator, Secretary Ickes has telegraphed Governor Dwight H. Green of Illinois that "it is imperative" that Illinois enact a petroleum conservation law.

"For several years I have been advocating the necessity of a petroleum conservation law by the oil-producing states. While oil conservation is essential at all times, in the emergency which the country now faces it is imperative. I urge you to give this problem your immediate personal attention to the end that Illinois enact a law to eliminate as far as practicable the waste of oil and gas and at the same time eliminate the drilling of unnecessary wells."

Bill to Promote Pipe-Line Construction

The United States House of Representatives on June 5 passed the Cole pipe line bill and sent it to the Senate where early and favorable action was expected. This is an administration measure designed to avert a possible shortage of petroleum and petroleum products in the eastern seaboard area.

The bill authorizes the Federal Government, through any government agency the president may designate, to construct or cause to be constructed any pipe-line facilities for the transportation of crude oil or petroleum products needed in the national defense emergency. The government is given specific authority to obtain rights-of-way under the right of eminent domain.

The bill states that whenever the president finds that the construction of a pipe line for the transportation of crude oil or its products moving in interstate commerce, or the completion, or extension of any pipe line already wholly or partly constructed, may be needed for national defense, he shall by proclamation declare such finding.

The bill further provides that in event it is impracticable for any private person, company, or corporation promptly and satisfactorily to construct, extend, or complete such pipe line, the president, if he finds such action desirable in the interest of national defense, may provide for the construction of such pipe line by such department or agency of the government as he may designate.

The bill also empowers the president to designate such agency of the government to operate the pipe lines that the government might construct as he deems best fitted for such function, and also provides that the pipe-line facilities involved may be sold or leased to private interests for operation.

Before passing the bill an amendment was appended that will limit to one year after expiration of the act the time in which the government through any of its agencies might operate or control such pipe lines as might be constructed with federal funds or which the government might take over for operation during the emergency.

Production of Oil Industry Dependent On Materials

Capacity of the petroleum industry to produce any desired amount of its products that may be needed is undisputed, but in order to keep its excess capacity always ahead of rising demand, the industry needs to buy nearly $1,000,000,000 worth of the materials, equipment, and supplies that are its normal annual purchases, according to a statement by the American Petroleum Institute.

The industry's capacity to produce is not a static phenomenon. Dynamic changes are part and parcel of its regular operation. For example, the oil business consumes millions of tons of iron and steel every year in its day-to-day work, more than is used by almost any other American industry.

To keep crude-oil reserves ahead of production, about 30,000 new wells are drilled each year. The 100,000,000 ft. of hole in these wells requires millions of feet of drill pipe and casing pipe. The derricks use thousands of tons of rig iron and steel. Hundreds of miles of pipe line must be laid each year to connect new oil fields, and other pipe lines, representing hundreds of thousands of tons of pipe, are required to meet changing transportation patterns. Thousands of tons of steel go into any oil tanker, and nearly 150 of them have been ordered for delivery within the next two years.

Huge alloy steel towers and pressure vessels for refineries are annual purchases that must be filled to keep the industry's refining capacity efficient. In the last four years alone the industry has built new refining capacity of 1,400,000 bbl. per day, equal to 30 percent of the present total capacity of its refineries. These refining purchases add up to thousands of additional tons of steel.

The petroleum industry's capacity is great and equal to any conceivable demands, it has been stated by many authorities, but this capacity, to be continually effective and with excess for emergencies, must be fed tremendous quantities of iron and steel, as well as a huge supply of other materials and equipment, the statement by the A.P.I. concludes.

PENBERTHY PRODUCTS

Reflex

DROP FORGED STEEL LIQUID LEVEL GAGE

EMPTY SPACE SHOWS **WHITE** | LIQUID SHOWS **BLACK**

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Transparent

DROP FORGED STEEL LIQUID LEVEL GAGE

USED TO OBSERVE COLOR AND DENSITY OF LIQUIDS UNDER HIGH PRESSURES, AND/OR TEMPERATURES

These gages are made of alloy temperature resisting steel and are of the highest quality throughout. Liquid chamber (both single and multiple section) is made from a solid block of steel to assure perfect alignment and rigidity. Frame has extra heavy beam at each end and glass chamber is accurately machined to contour of glass providing full metal backing for gaskets. Gage valves are drop forged steel with stainless trim.

These gages are available in any length and for various pressures and temperatures. All Penberthy gages conform with A. P. I.—A. S. M. E. requirements.

PENBERTHY INJECTOR CO.

DETROIT, MICHIGAN

Canadian Plant: WINDSOR, ONTARIO

MAJOR *Refining* ACTIVITIES

Percent Refining Capacity Operated

Western Division, 73.4 Percent **Central Division, 87.0 Percent** **Eastern Division, 89.1 Percent**

NOW operating as a simple-type, low-temperature, distillate recovery plant handling approximately 55,000,000 cu. ft. of gas per day, the capacity of the Corpus Christi Corporation plant in the Stratton field, Nueces County, Texas, is to be enlarged to 120,000,000 cu. ft.

The contract for the enlargement has been awarded to Stearns-Roger Manufacturing Company, Denver, Colorado.

With wet gas capacity increased to 120,000,000 cu. ft. per day, the plant will return 110,000,000 cu. ft. per day to the producing formation.

A complete absorption unit with stabilization is also to be added to the plant. The plant will be so designed as to provide for a later addition for complete butane recovery and splitting the butanes into *iso* and normal products.

Omar Refining Company's plant, Garber, Oklahoma, shut down for the last two years, has been reconditioned and will be opened in the near future. The plant has a crude oil capacity of 5000 bbl. and a 2000-bbl. cracking capacity. Oklahoma City field crude oil is processed.

A newly organized corporation, Texas Ranger Refinery, has purchased the Russell Oil Company lubricating plant at San Antonio, Texas. The corporation is headed by R. Robinson and R. D. Robinson, who have other plants in Waco and Rio Grande City.

A new refinery of the Paluxy Asphalt Company, Dallas, Texas, is nearing completion at Crupp, Mississippi, near Yazoo City. The company expects to have the plant on stream by the middle of June. Cracking equipment will be included in the 3500-bbl. plant and a complete line of asphalt products will be made. Also included in the plant's operation will be an ethyl-blending plant.

Crude oil will be supplied by Union Producing Company from the Tinsley field through a 4-in. pipe line recently completed.

The company is headed by E. Constantin, Jr.

New Mexico Asphalt and Refining Company is remodeling the former Midwest Refining Company plant (Tyreco) in Artesia, New Mexico.

The 2000-bbl. plant was recently acquired by the company from Black, Sivalls and Bryson, Inc., and Bethlehem Supply Company. The plant will receive its supply of crude oil from the Getty pool and Artesia area.

The Corpus Christi, Texas, refinery of the Bareco Oil Company, Tulsa, Oklahoma, has resumed operation. Constructed some three years ago, the plant has been closed for more than a year. It has a capacity of 10,000 bbl. and a 5500-bbl. Dubbs cracking unit.

A. B. Comstock is superintendent of the plant. He was formerly chemist at the company's Okmulgee, Oklahoma, refinery, at present shut down.

Magnolia Petroleum Company's Beaumont, Texas, refinery alkylation capacity has been expanded to produce a surplus of aviation-fuel alkylate for use at the Paulsboro, New Jersey, plant of Socony-Vacuum Oil Company, Inc., for blending with selected fuels.

Expansion of the plant will enable the refinery and the Paulsboro plant together to produce approximately 1,500,000 bbl. of 100 octane aviation gasoline per year.

M. J. Rathbone, president of Standard Oil Company of Louisiana, has announced the immediate construction of a large synthetic rubber and chemical project at its Baton Rouge refinery.

Rathbone made the announcement following a conference with Governor Sam Jones of Louisiana, in which details affecting the state and company jointly were worked out.

Financed without government assistance, the project is expected to cost between $12,000,000 and $15,000,000. An estimated 15 months will be needed to complete the project.

A 6000-bbl. per day new refining unit has been completed by Frontier Oil Corporation at its river road plant in Buffalo, New York.

Delivery of crude oil to the plant is from Illinois by pipe line to the Great Lakes and from there to the firm's Niagara River terminal by means of tankers and barges.

Construction of a $300,000 gas-condensate plant in the Williow Springs area of Gregg County, East Texas, is planned by the Lone Star Gas Company of Dallas, Texas.

Earlier in the month the company purchased a one-half interest in the properties from Roger Lacy of Longview, Texas. The purchase includes two gas-condensate wells, a drilling well, and considerable acreage.

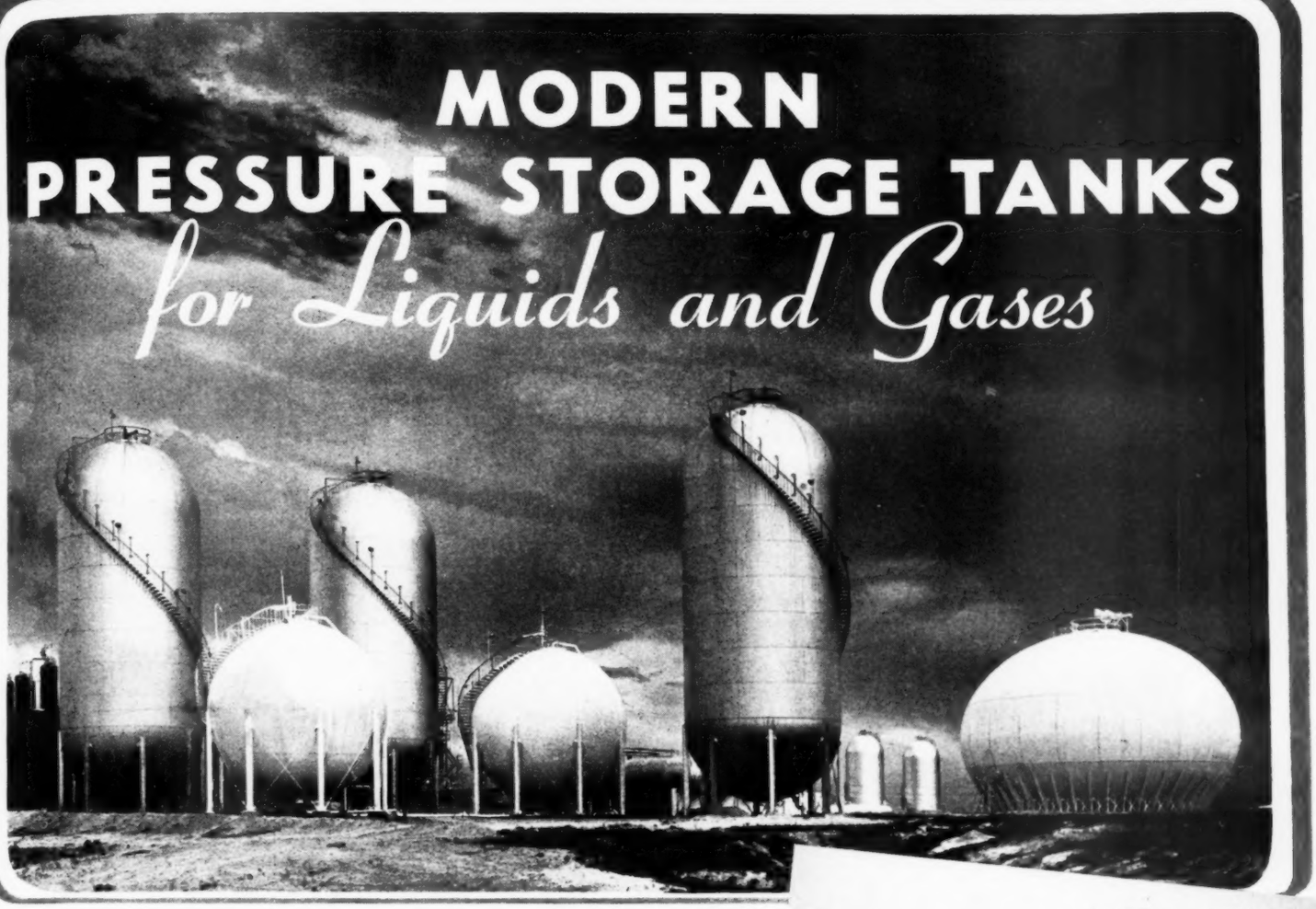
Crude Runs to Stills, Gasoline, Gas and Fuel Oil Stocks
Week Ended May 31, 1941
A.P.I. Figures

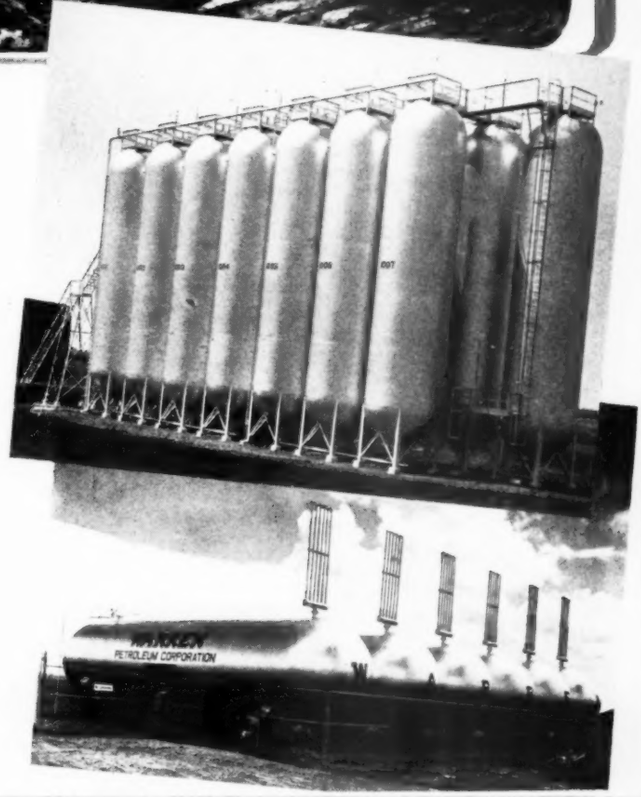
(Figures in thousands of bbl. of 42 gal. each)

DISTRICT	Percent Potential Capacity Reporting	Daily Avg. Crude Runs to Stills	Percent Operated of Total Capacity Reporting	Total Motor Fuel Stocks	Total Gas and Fuel Oil Stocks
East Coast	100.0	574	89.3	21,657	17,072
Appalachian	91.0	120	84.5	3,082	788
Ind., Ill., Ky.	90.2	626	93.4	17,007	3,527
Okla., Kans., Mo.	76.9	280	86.7	7,874	3,275
Inland Texas	59.6	120	71.9	2,281	1,654
Texas Gulf	89.2	877	91.8	14,119	13,822
Louisiana Gulf	97.6	148	92.5	3,420	2,740
No. La. and Ark.	51.5	48	92.3	573	813
Rocky Mountain	56.0	51	75.0	1,663	640
California	87.3	525	71.9	15,619	76,635
Reported	86.2	3,369	86.2	87,295	124,066
Estimated Unreported		330		6,550	2,215
*EST'D TOTAL U. S. MAY 31, 1941		3,699		(a)93,845	126,281
*EST'D TOTAL U. S. MAY 24, 1941		3,867		94,811	126,876
U. S. B. of M. MAY 31, 1940		**3,607		100,946	131,198

*Estimated Bureau of Mines basis.
**May, 1940, Daily average.
(a) Finished 86,311,000 bbl.; unfinished 7,534,000 bbl.

MODERN PRESSURE STORAGE TANKS *for Liquids and Gases*





Hortonspheroids—Hortonspheres—Horizontal and Vertical Bullets **. . . all of these tanks are quite dissimilar in appearance, but all have one important feature in common—the ability to protect their volatile contents against evaporation losses. This protection is accomplished by making use of the simple fact that no loss will occur if vapor does not escape from the tank. Thus, units of the types shown here are built to withstand the maximum vapor pressure of the product being stored and are equipped with a relief vent set to open above this pressure. Instead of allowing the air-vapor mixture to escape when the temperature rises, pressure is built up inside the tank. This principle is highly effective in eliminating breathing and boiling losses, and reducing or eliminating filling losses by the recondensing of vapor during filling.**

Hortonspheres are built in standard sizes from 1,000 to 15,000 bbl. for 20 to 250 lbs. per sq. in. pressure. Hortonspheroids for storing liquids at 2½ to 25 lbs. pressure are available in standard capacities of 2,500 to 100,000 bbls. Cylindrical tanks, or "bullets" are utilized where smaller sizes are adequate.

Call or write for complete information or quotations.

Top: One 10,000-bbl. Hortonspheroid, two 5,000-bbl. Hortonspheres, and three 12,000-bbl. vertical pressure tanks installed at a Texas refinery.

Center: Fifteen 1,000-bbl. butane tanks installed in Oklahoma. They are 12 ft. in diam., 42 ft. high.

Right: Six 1,000-lb. butane tanks at a marketing terminal. They operate at 80 lbs. pressure.

CHICAGO BRIDGE & IRON COMPANY

Fabricating Plants in BIRMINGHAM, CHICAGO and GREENVILLE, PA.

DALLAS.....1671 Praetorian Bldg.	CHICAGO.....2481 McCormick Bldg.	NEW YORK....3373-165 Broadway Bldg.
HOUSTON.....918 Richmond Avenue	DETROIT.....1538 Lafayette Bldg.	BOSTON...1535 Consolidated Gas Bldg.
TULSA.....1634 Hunt Bldg.	CLEVELAND...2251 Builder's Exchange	SAN FRANCISCO.....1064 Rialto Bldg.
BIRMINGHAM.....1570 N. 50th Street	PHILADELPHIA....1635-1700 Walnut St.	LOS ANGELES.....1446 Wm. Fox Bldg.

LICENSEES: Horton Steel Works, Limited, Fort Erie, Ontario, Canada; The Motherwell Bridge & Engineering Co., Ltd., Motherwell, Scotland; The Whessoe Foundry & Engineering Co., Ltd., London, England; Worms & Cie, Paris, France; Compagnia Tecnica Industrie Petroli, S.A.I. Rome, Italy.

MAJOR *Oil Field* ACTIVITIES

ATLANTIC REFINING COMPANY'S and Ray R. Rhodes' Carrie Slaughter Dean No. 1, wildcat well 3 miles south of the Duggan sector of the Slaughter field, Texas, has been officially called a new discovery. The well, 672 ft. from the north and 8423 ft. from the east lines of section 89, Lipscomb County School Lands Survey, is in Cochran County. The field is to be known as the Rhodes field. On test the discovery gauged 246 bbl. of 31-gravity oil, pumping, plus 25 percent water, in 24 hours. Production was from 5050-5111 ft.

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Columbia Carbon Company's wildcat well on the J. R. Sweezy farm in the Ravenswood district, Jackson County, Pennsylvania, has been completed in the Oriskany sand. The wildcat opens a large area for development as a new gas field. Corniferous lime was found at a depth of 4831 ft. and the Oriskany sand at 4944 ft. Approximately 15,000,000 cu. ft. of gas is produced per day. The well is a few miles southeast of Sandyville, Pennsylvania.

Whisenant and Trenchard appear to have opened a new Indiana oil field with their Florence McFadden No. 1, SW NW SW, in 16-6s-14w, which is in Black Township of Posey County, Indiana. Approximately 75 ft. of oil and oil-cut mud, including 12 ft. of free oil, was made by the well during a drill-stem test of Cypress saturation at 2477-2505 ft. The Aux Vases sand is also to be drilled and tested.

AVERAGE CRUDE OIL PRICES

California	
Kettleman Hills	$1.23-1.29
Playa Del Rey	.80- .87
Coalinga	.73-1.13
Wilmington	.68-1.24
Montana	1.00-1.15
Wyoming	.40-1.30
Colorado	.95- .97
New Mexico	.70-1.12
Texas	
North Central	.78-1.18
Panhandle	.70-1.12
West Texas	.70-1.12
Gulf Coast	.93-1.48
Darst Creek	1.14
East Texas	1.27
Talco	.79
Kansas	.70-1.25
Oklahoma	.70-1.25
Arkansas	.68-1.08
Louisiana	
Rodessa	.88-1.20
Gulf Coast	.94-1.48
North Louisiana	1.20-1.30
Illinois	1.22-1.37
Kentucky	1.32-1.40
Indiana	1.22
Ohio	
Lima	1.17
Michigan	1.24-1.44
Pennsylvania	
Bradford	2.55
Southwest	2.20
Eureka	2.14
Buckeye	2.10
Corning	1.31

DAILY AVERAGE CRUDE OIL PRODUCTION

Data Supplied by A.P.I.

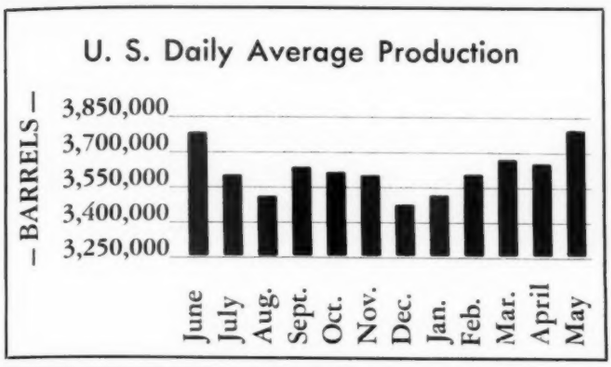
(Figures in bbl. of 42 gal. each.)

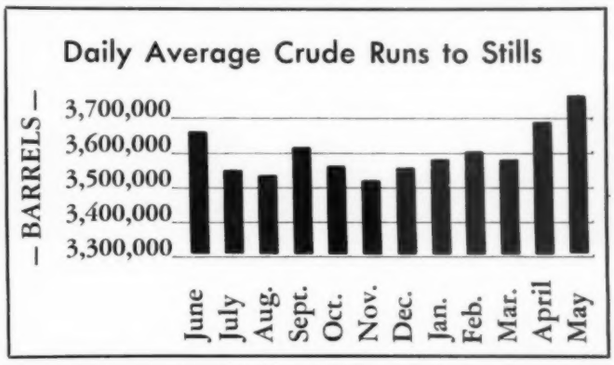
	[1]B. of M. Calculated Requirements (May)	Week Ended May 31, 1941	Week Ended May 3, 1941	Week Ended June 1, 1940
Oklahoma	440,000	[2]413,350	408,650	422,350
Kansas	213,900	[2]208,900	209,100	158,850
Nebraska	4,800	[2] 4,300	4,200	100
Panhandle Texas		77,800	76,850	67,450
North Texas		99,650	95,850	104,550
West Central Texas		30,000	29,950	32,550
West Texas		259,100	210,250	236,750
East Central Texas		79,500	74,950	79,050
East Texas		373,700	304,000	396,600
Southwest Texas		209,850	175,100	219,350
Coastal Texas		276,650	232,800	228,250
TOTAL TEXAS	1,382,200	1,406,250	1,199,750	1,364,550
North Louisiana		73,200	72,100	70,100
Coastal Louisiana		252,600	235,450	237,950
TOTAL LA.	320,300	325,800	307,550	308,050
Arkansas	83,900	73,200	72,350	71,900
Mississippi	22,900	[2] 27,500	28,450	9,350
Illinois	336,100	341,200	322,900	449,600
Indiana	23,900	[2] 22,000	21,800	11,900
Eastern (not incl. Ill. and Ind.)	102,300	94,150	93,250	98,900
Michigan	40,000	38,000	38,000	59,150
Wyoming	90,900	85,150	73,600	72,200
Montana	21,300	19,050	19,100	17,900
Colorado	5,200	4,000	3,800	3,300
New Mexico	113,900	113,050	108,800	107,350
TOTAL EAST OF CALIF.	3,201,600	3,175,900	2,911,300	3,155,450
California	598,100	610,200	595,800	593,600
TOTAL U. S.	3,799,700	3,786,100	3,507,100	3,749,050

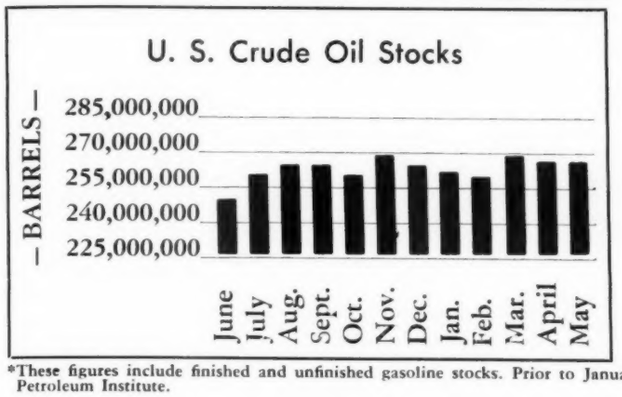
[1]These are U. S. Bureau of Mines' calculations of the requirements of domestic crude oil based upon certain premises outlined in its detailed forecast for the month of May. As requirements may be supplied either from stocks, or from new production, contemplated withdrawals from crude oil inventories must be deducted from the Bureau's estimated requirements to determine the amount of new crude to be produced.

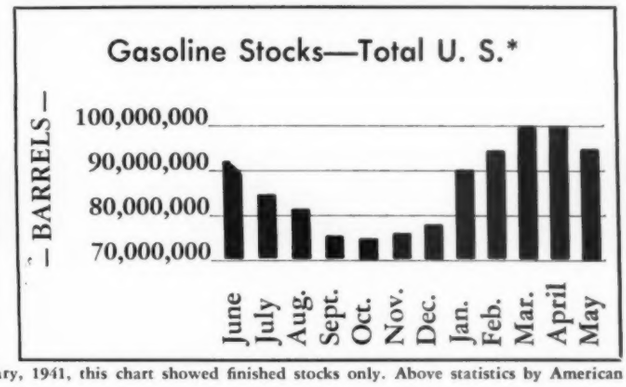
[2]Oklahoma, Kansas, Nebraska, Mississippi, and Indiana figures are for week ended 7 a. m. May 28.

PETROLEUM *Statistics* AND FIELD *Operations*









*These figures include finished and unfinished gasoline stocks. Prior to January, 1941, this chart showed finished stocks only. Above statistics by American Petroleum Institute.

Summarized Operations in Active Fields for May, 1941

Fields	Completions	Producers	Rigs	Drilling Wells	Depth of Production	No. Casing Strings	Gravity of Oil	Type of Tool Used
TEXAS								
East Texas	56	54	9	33	3500-3700	2	40	Rotary
Duval County	17	11	3	9	1554-2900	2	22	Rotary
Ector County	31	31	15	42	3675-4377	2 and 3	32-36	Rot.-Cab.
Panhandle	55	54	25	81	1700-3900	2	40	Rotary
Nueces County	28	26	3	8	3922-5878	2 or 3	21-54	Rotary
K. M. A. Field	17	16	8	31	3730-3935	2	42-43	Rot.-Cab.
Hawkins Field	38	38	13	22	4495-4912	2	19-29	Rotary
OKLAHOMA								
Fitts Pool	6	2	2	4	1800-4488	2 or 3	38	Rotary
KANSAS								
Russell County	36	27	7	20	2926-3435	2 and 5	32-37	Rot.-Cab.
Rice County	17	12	5	19	3222-4085	2 and 5	42-48	Rot.-Cab.
Barton County	40	29	19	35	3290-3518	2	39-42	Rot.-Cab.
ILLINOIS								
Central Illinois	280	221	243	132	1425-4100	2	36-38	Rot.-Cab.
NEW MEXICO								
Lea County	16	14	10	24	3150-4030	3	30-34	Rot.-Cab.
CALIFORNIA								
Kettleman Hills	1	1	4	8	8300-8730	3 or 4	40	Rotary
Wilmington	27	27	13	18	3500-4000	2 and 3	18-20	Rotary

Field Activities by States for May, 1941

State	Completions		Producers		Locations		Rigs		Drilling Wells		Production, 1940 (In Barrels)
	May	April	May	April	May	April	May	April	May	April	
Arkansas	14	11	11	3	15	21	6	5	30	25	25,699,000
California	109	93	104	85	99	115	106	103	161	158	224,029,629
Colorado	1	1	1	0	....	....	3	3	30	35	1,369,788
Illinois	280	307	221	243	404	416	243	312	132	157	146,572,938
Indiana	60	44	35	28	....	....	13	11	78	67	4,946,384
Kansas	235	189	166	153	204	227	43	38	301	248	65,602,452
Kentucky	39	29	20	11	....	....	10	8	96	88	5,282,335
Louisiana	145	112	100	77	157	169	50	46	295	319	103,738,728
Michigan	74	71	24	44	66	75	40	40	153	149	19,768,984
Mississippi	26	10	18	8	....	....	5	3	35	27	4,313,159
Montana	9	15	9	13	....	....	3	5	30	65	6,663,872
Nebraska	11	7	6	4	9	8	4	3	18	20	267,533
New Mexico	34	35	28	30	30	36	19	18	107	117	38,893,898
New York	83*	64*	83*	64*	....	....	11	7	81	60	4,240,441
Ohio	134	159	98	127	....	....	43	51	186	201	3,132,280
Oklahoma	221	189	162	125	171	231	57	47	304	296	152,516,049
Pennsylvania	272*	206*	257*	197*	....	....	15	7	93	60	17,987,217
Texas	1015	887	776	671	803	1291	721	614	1973	1831	490,101,261
West Virginia	60	56	57	48	....	....	23	25	165	154	3,586,653
Wyoming	7	7	7	7	....	....	11	13	57	65	25,863,538
Total	2829	2492	2173	1935	1928	2589	1426	1352	4325	4082	1,344,576,159

*Includes water-intake and pressure wells.

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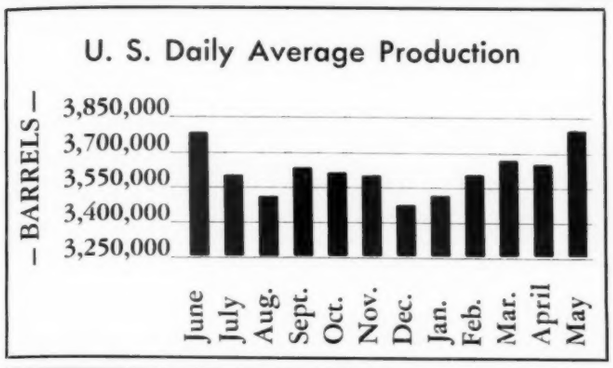

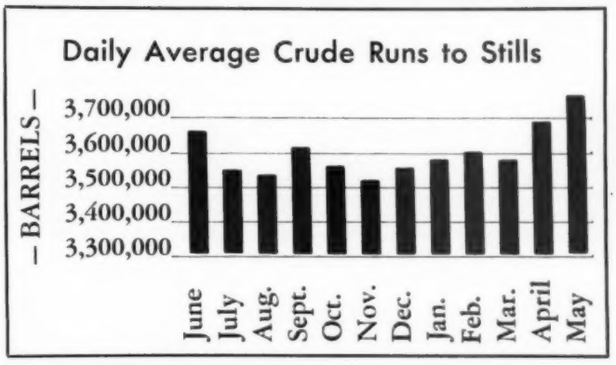

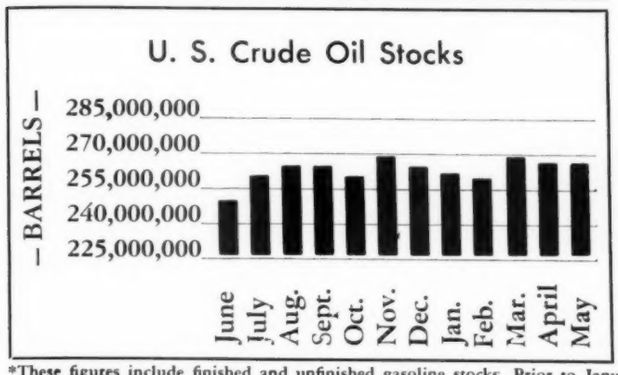

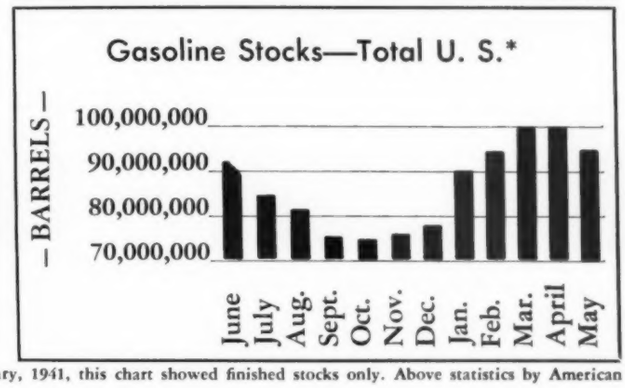

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Mississippi	26	10	18	8	....	....	5	3	35	27	4,313,159
Montana	9	15	9	13	....	....	3	5	30	65	6,663,872
Nebraska	11	7	6	4	9	8	4	3	18	20	267,533
New Mexico	34	35	28	30	30	36	19	18	107	117	38,893,898
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Oklahoma	221	189	162	125	171	231	57	47	304	296	152,516,049
Pennsylvania	272*	206*	257*	197*	....	....	15	7	93	60	17,987,217
Texas	1015	887	776	671	803	1291	721	614	1973	1831	490,101,261
West Virginia	60	56	57	48	....	....	23	25	165	154	3,586,653
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Total	2829	2492	2173	1935	1928	2589	1426	1352	4325	4082	1,344,576,159

*Includes water-intake and pressure wells.

MAJOR *Pipe Line* ACTIVITIES

FORD, BACON AND DAVIS, INC. construction engineers, announced they have been awarded the contract for laying of two large "defense" pipe lines at a cost of more than $22,000,000. Construction is to begin shortly on the pipe lines—one for gasoline and the other for natural gas—through the heart of the industrial South.

The gasoline line will be laid from Louisiana refineries to Greensboro, North Carolina, and possibly to the naval base at Norfolk, Virginia. Operation of the line will be supervised by the Plantation Pipe Line Company, jointly owned by Standard Oil Company of New Jersey, Standard Oil Company of Kentucky, and Shell Union Oil Company.

Running from the Joaquin field of Shelby County, east Texas, into eastern Georgia, the gas line will comprise hookups and compressor station additions to the Southern Gas Company system.

Construction of the lines is intended to relieve bottlenecks now developing in southern industries due to increasing defense industrial production.

The gas line system, including many existing facilities, is expected to cost from $7,000,000 and $8,000,000. Estimates for laying the gasoline line total approximately $15,000,000. Orders for pipe already placed amount to $6,000,000.

Inability of Plantation to obtain rights-of-way across railroads in many of the southern states delayed placing of the contract. Recent demands by the Federal Government for the construction of the gasoline line as a "vital necessity" have caused company officials to believe they can continue with construction fully confident that rights-of-way can be obtained.

Gulf Refining Company, Tulsa Pipe Line Division, will construct 12 loops of 10-in. pipe, totaling 202 miles, to increase the capacity of the crude oil trunk line between Glenn Pool, Oklahoma, and Dublin, Indiana, by 10,000 bbl.

To J. R. Stewart Construction Company, The Texas-Empire Pipe Line Company has granted a contract for construction of 8 miles of 10-in. pipe line replacing 8 miles of 12-in. that is to be taken up.

Standard Oil Company of New Jersey has awarded contracts to Williams Brothers Corporation, Tulsa, Oklahoma, and Oklahoma Contracting Company, Dallas, Texas, for construction of a 12-in. pipe line from Portland, Maine, to Montreal.

The main line will be 250 miles in length and will have a capacity of 50,000 bbl. of crude oil per day, with a maximum capacity in summer months of 60,000 bbl.

Crude oil from Gulf Coast and South American fields will be delivered by tanker to a marine terminal at Portland. From the latter point the crude oil will be piped to Montreal for distribution to the several refineries in that area. The project is designed primarily to insure deliveries of oil supplies to Canada in view of the growing tanker shortage because of the recent transfer of these carriers to the Maritime Commission.

The pipe line shortcut will save about one-third of the normal tanker voyage from Gulf ports to Montreal. In addition to the longer haul at present, tankers are unable to make deliveries up the St. Lawrence River during certain winter months.

Orders for the pipe have already been placed with the Youngstown Sheet and Tube Company and with Spang Chalfant Company.

The Standard Oil Company of Indiana announces the beginning of construction on two gasoline pipe lines, from Burlington Junction, Missouri, to Des Moines, Iowa, and from Council Bluffs, Iowa, to Sioux Falls, South Dakota, and on two pipe-line terminals at Des Moines and Sioux Falls.

Six-inch pipe will be laid and will extend the existing main line from the refinery at Sugar Creek, Missouri, near Kansas City, Missouri, to Council Bluffs. From Burlington Junction to Des Moines is 111 miles and the extension from Council Bluffs to Sioux Falls will be 167 miles.

The terminals will distribute Standard products by tank car and truck to bulk plants as far as 200 miles distant.

A 200 mile natural gas pipe line from production in Jackson County, Southwest Texas, to provide fuel for the company's refining in the Beaumont, Texas, area is to be placed under immediate construction by the Magnolia Petroleum Company. To be laid by the Magnolia production department, the line is expected to be in operation by January 1.

The major portion of the line will be of 14-in. pipe, but near Beaumont some will be 16-in.

Also planned by Magnolia is construction of a 53-mile crude oil pipe-line system to the new Abell pool in northern Pecos County, West Texas.

Imminent danger of a transportation bottleneck being created by increased sale of gas and oil and decreasing transportation facilities, which would create a shortage of gasoline and fuel oil on the Atlantic Seaboard and also force a reduction in production in Texas, Oklahoma, and Louisiana, would be prevented by enactment of the bill introduced by Representative William P. Cole, Jr., of Maryland. The bill, which received complete approval of the president and already has been passed by the House, gives the gasoline and crude oil pipe-line companies the right of eminent domain in states where they do not already have this power and authorizes the president to allocate funds for the construction of new lines. Also provided for in the bill are priorities of pipe and other construction materials needed.

A result of the bill's passage would be the construction of pipe lines totaling in expenditures as much as $300,000,000. Not yet announced, but agreed upon as being needed by the committee set-up recently by the American Petroleum Institute to represent the oil industry, is a crude oil pipe line from East Texas to some point on the Atlantic seaboard, possibly North Carolina. This line would be the most important of the proposed lines and also the largest crude oil line in the Nation, because tentative plans call for 20- or 24-in. pipe.

A second line, not yet announced but believed certain of construction, is a crude oil line, shorter than the first, from Ohio to a point on the eastern seaboard where it would connect with laterals to the large eastern cities. Supplies for the line in Ohio would come from the Mid-Continent and Illinois fields.

A line from Wood River, Illinois, has been tentatively planned to a point near New York City for gasoline transportation. Gasoline could be transported from the Illinois refining center near St. Louis to the metropolitan area of New York through this line. Additional supplies of gasoline could be taken from Oklahoma refineries if needed.

Construction also is to begin in the near future on a natural gas and a gasoline line, as a result of this legislation. Plantation Pipe Line Company's gasoline line will run from Baton Rouge, Louisiana, to Greensboro, North Carolina, as discussed elsewhere on this page.

THE Petroleum Engineer

JUNE, 1941

Refinery Piping . . . Design of Bottoms Line From Still to Fractionators

Petroleum Engineer Exclusive

☆ Piping in heat exchangers should be given adequate consideration — Physical properties of denuded material play part in proper design

by R. G. Lovell, Development Engineer, Hancock Oil Company of California

IN CONSIDERING the design of the piping by which the still bottoms are moved from the primary distillation unit through the tube heater to the fractionating tower we again find that friction loss is not of particular importance on the discharge side of the pump but is of some importance on the suction side, although the suction conditions are somewhat relieved because of a change in the nature of the stock being handled.

For present purposes it will not be necessary to make an accurate calculation of the temperature of the bottoms from the flash chamber. It is near enough to the actual to assume that, if the flashing-off occurs at 250°F., the temperature of the bottoms will be approximately 225°F. This temperature might offer serious suction difficulties in the line from primary heat exchangers to flash tower, but enough of the lighter fractions were evaporated in the flash distillation so that there need be no concern if the pressure at the suction end of the pump is not below atmospheric; in short, if we provide flooded suction.

The volume of oil to be handled can be assumed to be 95 percent of the original charge of 10,000 bbl. per day. This new volume figure, then, is 9500 bbl. per day, or 275 gal. per min. But this volume has been subject to increase and the specific gravity, consequently, decreased, both occurring as a result of the increase in temperature to 225°F. Obviously, the viscosity has also been reduced. The exact amount of any one or all three of these changes is of little importance on the discharge end of a line, but it is essential to know how to evaluate the effects of the temperature increase. Otherwise how is one to know that they are only of minor importance?

R. G. LOVELL

received his academic training in New York and served several of the larger mining and milling companies of New Mexico, Arizona, and the Republic of Mexico as power engineer and master mechanic from 1908 to 1917, then saw military service in the engineering corps until 1919 —Returning from the war he became affiliated with the oil refining industry, first with Standard Oil Company of California as refinery construction engineer and later with a foreign company —Later he was made assistant to the chief engineer of Pan American Petroleum and Transport Company for the construction of their California processing properties—He has been with The Hancock Oil Company of California since that time—Lovell is the senior instructor of the class in practical petroleum refining, which he organized several years ago, for the Trade Extension Division of the Long Beach High Schools—The class is attended by employees of the many companies operating in the southern California fields.

By use of the specific gravity-temperature chart (Fig. 1)it may be observed that the gravity has been changed from 25° to 35° A.P.I. and the specific gravity has decreased from 0.91 to 0.85. The weight in lb. per gal. of the oil has dropped from 7.6 to 7.1. Obviously, the increase in volume will be in practically the same percentage as the decrease in weight per unit of volume. This is about 7 percent. This can, and should be, checked by the other diagram, Fig. 2, the expansion-temperature chart. We have, then, 275 gal. per min. plus 7 percent, or 294 gal. per min. From experience we can safely say that either a Pacific Coast or a Mid-Continent crude oil that has a viscosity at ordinary temperatures of 250 S.S.U. (Seconds Saybolt Universal) would have a viscosity of not more than 45 S.S.U. at this higher temperature of 225°F. Viscosity becomes, therefore, virtually a negligible factor and the head-loss-due-to-friction has become very much less than with the cold oil. But the change in specific gravity because of the higher temperature has not changed the head loss at all. The same total weight of oil must be handled per unit

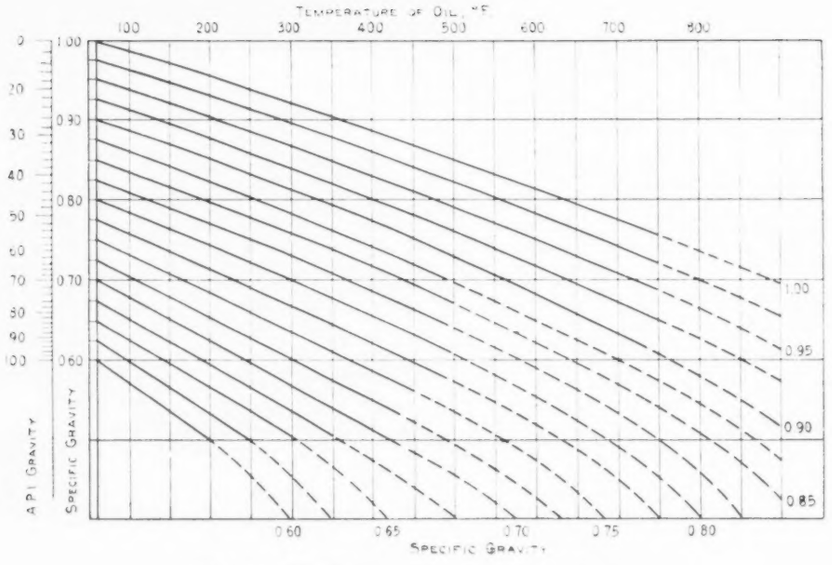


Fig. 1. Specific gravity-temperature chart

of time as before. Consequently, we have made an overall gain by the reduction in viscosity due to temperature.

From Table 1 it can be seen that 4-in. pipe offers an entirely reasonable condition. It should, of course, be kept in mind that the figures in the table are based upon pumping water and, for liquids lighter than water, and of negligible viscosity, the head-loss-due-to-friction value should be multiplied by the actual specific gravity. Four-in. pipe will be suitable, however, only if the liquid level in the flash chamber is to be 6 ft. or more above the pump suction and the line is not more than 100 ft. in length. Good practice is to use 6-in. lightweight pipe. A suction chamber near the pump is also good practice in this case although not as necessary as in the line from crude storage to primary charging pump, described in the article by the writer, appearing in the May issue of *The Petroleum Engineer.*

Insulation

Only in rare cases is there any advantage in insulating the section of line from flash chamber to pump and on to the tube heater. The heat loss would be slight because of the comparatively low temperature differential between the oil and the outside air. Length of the line and velocity of the oil would, of course, have a bearing on this, but the velocity with 300 gal. per min. through a 6-in. line would be 3.5 ft. per sec., which does not allow a great heat loss.

Within the Heater

The piping within the heater is a part of the line that is, perhaps, of greater importance than any other line previously discussed. To calculate the size of pipe or tubing to be used is by no means difficult. It is considered strictly an engineering job but we shall try to show how easy it is to arrive at a size that will give overall satisfaction.

In previous calculations for pipe size we have endeavored to avoid velocities that caused turbulent flow, as it was shown how turbulence increased friction loss. Now we have a condition that is just the reverse. The duty of the pipe or tubing in the heater is to offer such flow conditions that the necessary heat can be transferred from the furnace gases to the oil with maximum *heating* efficiency. As has been pointed out in earlier articles it is necessary in order to accomplish this efficiency, to change the position of each drop or layer of oil rapidly. That is: a layer of oil that is traveling next to the inside wall of the tube at one instant and has, therefore, absorbed heat, must be forced to commingle with the oil in the center of the tube and be replaced in position for heat absorption by some of this inside oil. This makes necessary a condition of turbulence that, further, is an assurance of freedom from local overheating and the consequent blistered tubes.

Specific Heat

Another physical property, specific heat, is now to be considered. This property must be clearly understood in order to realize that turbulence is even more necessary in an oil heater than in a steam boiler. Specific heat, expressed in British thermal units (B.t.u.), is the amount of heat required to raise 1 lb. of a substance through 1°F. temperature. Unity (1) is the amount required for water. The specific heat of most petroleum oils is about 0.5. Applying the definition, it requires only half as much heat to raise the temperature of a pound of oil by one degree as is required for water. Or, in other words, one pound of oil will absorb only ½ of 1 B.t.u. before its temperature is raised one degree. By the same reasoning, as a pound of the oil has had its temperature raised quicker it will more quickly have lost some of its ability to absorb more heat than would water. The rapidity of the heat transfer per unit of exposed tube area is dependent upon the temperature difference between the furnace gases and the oil. Thus we see that relatively high velocity of the oil in the tubes is an advantage in that it makes the heat transfer more rapid and reduces the possibility of local overheating.

Crude oil heaters should offer a velocity of from 4 to 7 ft. per sec., depending upon the nature of the crude oil and the maximum temperature required. The calculation of this velocity is an easy matter. Neither specific gravity nor viscosity enter into it in any way. It is entirely a case of a definite volume of oil required to pass through a given cross-sectional area in a stated time. It will be helpful to make the calculation for the problem being discussed just to become conversant with the operation. Afterward the table may be used.

The oil will have become heated to about 500°F. at the time it leaves the heater and, in the calculation, to use the increased volume at the maximum temperature will do no harm. Refer again to the expansion-temperature chart and pick up the 35° A.P.I. oil curve where we had left it for the calculation of the increased volume at 225°F. Observe that the increased volume at 500°F. over that at 60°F. is 28 percent. There has been, therefore, an increase over the volume at 225°F. temperature of the difference between 7 percent and 28 percent, or 21 percent. The volume at 225°F. was 300 gal. per min. and $300 \times 1.21 = 360$ gal. per min. approximately. Hence, 360×231 (cu. in. in a gal.) = 83,160 cu. in. per min., or 1386 cu. in. per second.

It will be obvious that this volume of oil per second will be required, in order to pass through a known cross-sectional area, to travel at a velocity in inches per second of as many as the number of times the area in sq. in. is contained in the volume in cu. inches. Pipe of 5-in. diameter has a transverse internal area of 20 sq. in. Dividing the 1386 cu. in. per second of flow by the 20 sq. in. of cross-sectional area we

have 69.3 in. per sec., or 5.8 ft. per second. This is an altogether satisfactory velocity.

The accompanying table will be found convenient for determining these velocities as well as other figures of friction loss. All values refer to water and can be applied as well for oils that are at temperatures high enough to reduce viscosities to negligible figures. Correction in friction loss figures must be made for reduced specific gravities by multiplying the values shown by the actual specific gravity (not A.P.I.) of the oil.

Transfer Line, Heater to Fractionator

Another element now enters into the proposition, which is the steam for distillation. This subject was discussed in previous articles,[1] but, as it is so clearly a part of a piping problem, we shall now approach it from that angle. The duty of the steam is entirely *chemical* but, in the performance of its duty, certain *physical* changes are effected in the oil. If adequate facilities are provided, these physical changes can be effected with a definite and calculable advantage to the distillation process.

[1] "Refinery Steam and Its Efficient Utilization," by R. G. Lovell, *The Petroleum Engineer*, June and August, 1940, issues.

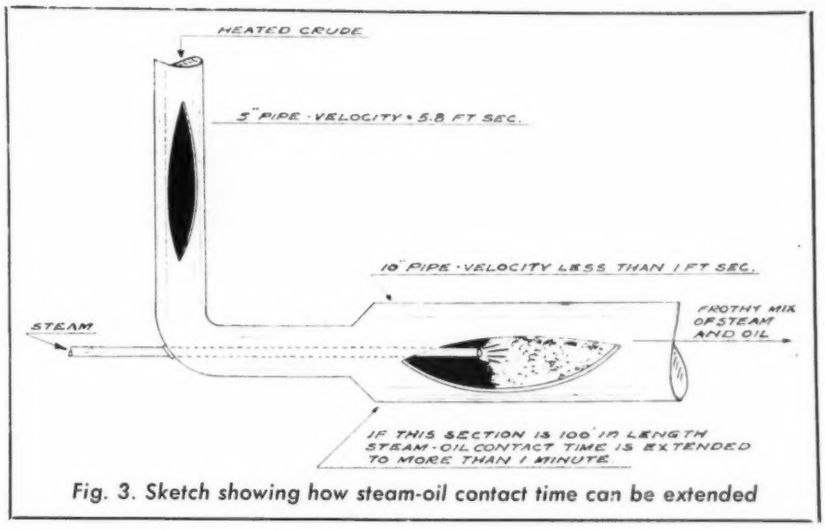
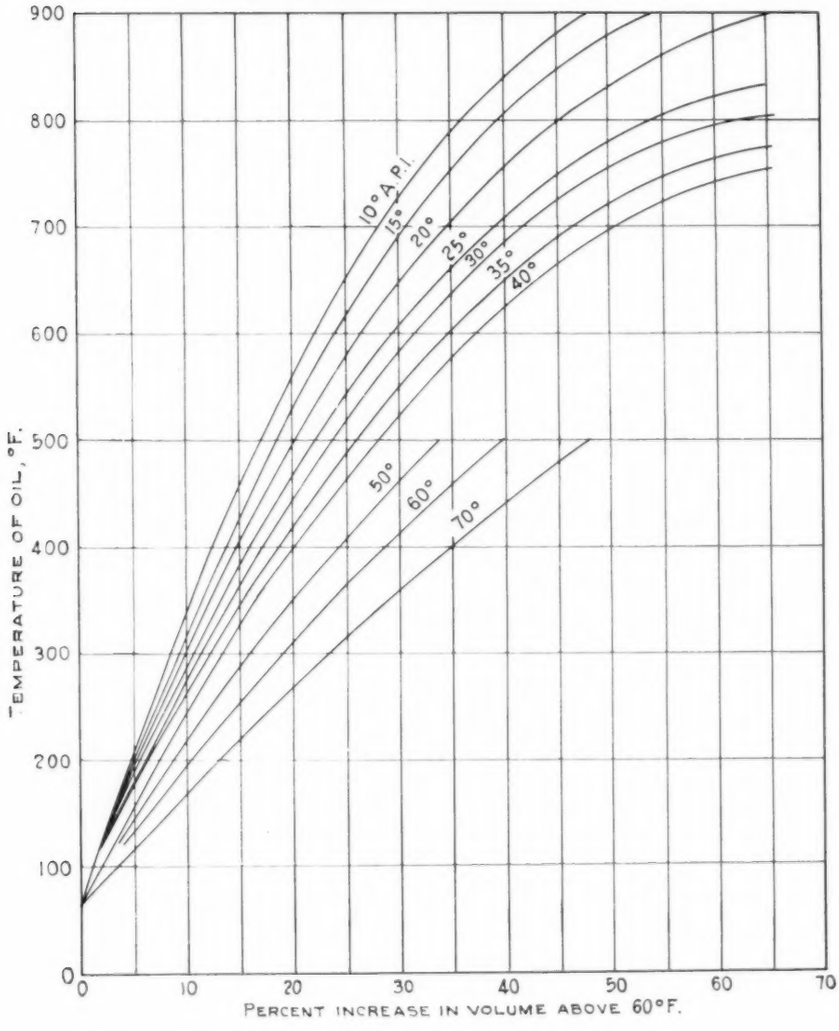

HEATED CRUDE
5" PIPE · VELOCITY = 5.8 FT SEC.
10" PIPE · VELOCITY LESS THAN 1 FT SEC.
STEAM
FROTHY MIX OF STEAM AND OIL
IF THIS SECTION IS 100' IN LENGTH STEAM-OIL CONTACT TIME IS EXTENDED TO MORE THAN 1 MINUTE

Fig. 3. Sketch showing how steam-oil contact time can be extended

Fig. 2. Expansion-temperature chart



It has long been accepted that there should be some advantage in introducing the distillation steam well back of the tower. The idea, no doubt, remained from the shell still days when it was standard practice to introduce a large part of the steam at the bottom of the still. The steam entered at high velocity because it was usually from a high-pressure source; due to this high velocity, the steam created a violent mechanical agitation that was effective in reducing trouble from shell blisters.

Many attempts have been made, since the shell still has been supplanted by the continuous tube heater, to reduce tube failures by introducing either steam or water into the line ahead of the heater, but without success. In fact, burned tubes, particularly in the radiant zones, seemed to become more prevalent. The reason for this seeming paradox is clear. Bottom steam in the shell still performed its function much as does the compressed air in the conventional air lift system of water well pumping. First, by giving the oil a mechanical upward kick (because of its high entrance velocity) and second by reducing the specific gravity of the oil immediately surrounding it. The frothy mixture thus produced in the contact area would have caused trouble from localized overheating at the bottom of the still had it remained there for any length of time. But the froth, for the reasons given, was quickly and constantly replaced by the liquid oil coming down from the upper areas of the still where it had lost heat from partial vaporization. It must also be remembered that, when the distillation process was continuous, the amount of oil in the still was maintained at the same level regardless of the rate of evaporation but that, on the other hand, the

TABLE I

Nominal pipe size, ... / Internal area, sq. in.	2-in. 3.365			2½-in. 4.788			3-in. 7.393			4-in. 12.73			5-in. 20.01			6-in. 28.89		
Quantity of fluid, gal. per min.	Velocity, ft. per sec.	Velocity head in ft.	Head loss, ft. per 100 ft.	Velocity, ft. per sec.	Velocity head in ft.	Head loss, ft. per 100 ft.	Velocity, ft. per sec.	Velocity head in ft.	Head loss, ft. per 100 ft.	Velocity, ft. per sec.	Velocity head in ft.	Head loss, ft. per 100 ft.	Velocity, ft. per sec.	Velocity head in ft.	Head loss, ft. per 100 ft.	Velocity, ft. per sec.	Velocity head in ft.	Head loss, ft. per 100 ft.
60	6.13	0.58	13.9															
65	6.64	0.68	16.1															
70	7.15	0.79	18.4															
75	7.66	0.91	20.9															
80	8.17	1.04	23.7	5.88	0.54	9.8												
90	9.19	1.31	29.4	6.54	0.66	12.0												
100	10.21	1.62	35.8															
110	11.23	1.96	42.9	7.84	0.95	16.0	5.45	0.46	7.0									
120	12.25	2.33	50.0															
130	13.28	2.73	58.0	9.15	1.30	22.3	6.35	0.63	9.2									
140	14.30	3.17	67.0															
150	15.32	3.64	76.0															
160	16.34	4.14	86.0	10.46	1.70	29.0	7.26	0.82	11.8									
170	17.36	4.67	96.0															
180	18.38	5.23	107.0	11.76	2.15	35.7	8.17	1.04	14.8									
190	19.40	5.84	118.0															
200	20.42	6.46	129.0	13.07	2.66	43.1	9.08	1.28	17.8	5.11	0.41	4.4						
220	22.47	7.82	154.0	14.38	3.22	52.0	9.99	1.55	21.3	5.62	0.49	5.2						
240	24.51	8.31	182.0	15.69	3.82	61.0	10.89	1.84	25.1	6.13	0.58	6.2						
260	26.55	10.90	211.0	16.99	4.45	70.0	11.80	2.16	29.1	6.64	0.69	7.2						
280				18.30	5.20	81.0	12.71	2.51	33.4	7.15	0.79	8.2						
300				19.61	5.98	92.0	13.62	2.88	38.0	7.66	0.91	9.4						
320				20.92	6.80	103.0	14.52	3.28	42.8	8.17	1.04	10.5						
340				22.22	7.68	116.0	15.43	3.71	47.9	8.68	1.17	11.7						
360				23.53	8.60	128.0	16.34	4.15	53.0	9.19	1.31	13.1						
380				24.84	9.60	142.0	17.25	4.62	59.0									
400				26.14	10.62	156.0	18.16	5.11	65.0	10.21	1.62	16.0	6.54	0.66	5.4			
420				27.45	11.70	171.0	19.06	5.64	71.0									
440				28.76	12.85	186.0	19.97	6.20	77.8									
450										11.49	2.05	19.8	7.35	0.84	6.7	5.11	0.40	2.74
460				30.07	14.00	205.0	20.88	6.78	84.0									
480							21.79	7.38	91.0									
500							22.70	8.00	98.0	12.77	2.53	24.0	8.17	1.04	8.1	5.68	0.50	2.99
550							24.96	9.70	117.0	14.04	3.06	28.7	8.99	1.26	9.6	6.25	0.60	3.96
600							27.23	11.50	137.0	15.32	3.65	33.7	9.80	1.49	11.4	6.81	0.72	4.65
650										16.59	4.28	39.0	10.62	1.75	13.2			
700										17.87	4.96	44.9	11.44	2.03	15.1	7.95	0.98	6.21
750										19.15	5.70	51.0	12.26	2.34	17.2			
800										20.42	6.48	57.0	13.07	2.66	19.4	9.08	1.28	7.96
850										21.70	7.30	64.0	13.89	2.99	21.7			
900										22.98	8.20	71.0	14.71	3.36	24.0	10.22	1.62	9.92
950													15.52	3.74	26.7			
1000													16.34	4.15	29.2	11.35	1.99	12.02
1100													17.97	5.00	34.9			
1200													19.61	5.96	40.9	13.61	2.88	16.80
1400																15.90	3.91	22.60
1500																17.02	4.50	25.60

amount of steam used was in proportion to the amount of overhead stocks being taken off per unit of time.

The fundamental reason for the burned tubes was that the froth, having a much lower specific heat than the liquid oil, could not absorb the furnace heat fast enough. It will also be obvious that the froth could return to liquid only by reason of sufficient pressure or reduction of temperature by contact with colder oil. With the relatively low velocities in general use some years ago the pressure was not sufficient to keep down the frothing tendency and there was certainly no opportunity, in a tube heater, for contact with a colder oil.

The time element certainly has much to do with the efficiency of the stripping operation. Manifestly, then, there will be some advantage in providing more time for intimate contact between the heated oil and the steam. How this can be accomplished is shown in Fig. 3.

The extra cost of the larger section of line is entirely justified by the improvement in operating efficiency; and, if lightweight pipe is used, the cost is not likely to be any more than with the standard weight in 5-in. size. Heat insulation becomes somewhat more important with this scheme because of the reduction in heat of the oil by transfer to the steam. The same general rules and suggestions for types of valves and fittings that have been made in previous articles will apply to this line.

Some quizzical soul, when analyzing this idea, is bound to wonder why water could not be used and save the expense of boilers. There are no insurmountable reasons why water could not be used, but to do so requires that some further provisions must be made for accommodating the enormous expansion of the water when it turns into steam in the line. The idea is, by no means, impracticable, particularly with the accurate proportioning devices that are now available. A rough idea of the problem can be had from consideration of the fact that about 2 gal. of water per minute would need to be put into the line. When this amount of water quickly becomes steam it is rather certain to require plenty of room, the exact amount of which may be calculated. Additional heat would also be required in the crude to supply the latent heat of vaporization of the water. The approximate amount would be 15,000 B.t.u. per minute.

CORRECTION: In the lower left-hand corner of Fig. 1 of "Refinery Piping . . . Design of Line From Charging Pumps to Flash Towers" by R. G. Lovell, the line from the base of the main fractionating tower should be shown as tying-in in order to supply the "hot bottoms" and "charge stock to cracking." This article appeared in the May, 1941, issue of *The Petroleum Engineer*.

General view of Republic Production Company's plant in Joe's Lake Field, Texas

Pressure Maintenance Plant Includes Crude Oil Stabilization

Two 300-hp. and one 500-hp. angle-type compressor units balanced dynamically to reduce vibration caused by poor soil

by Frank H. Love
Managing Editor

IN THE Joe's Lake field, Tyler County, Texas, the pressure maintenance, crude stabilization, and gasoline extraction plant of the Republic Production Company is now in full operation. The plant is owned jointly by Republic Production Company and Houston Oil Company and is operated by the former. Its principal function is the pressure maintenance of the producing formation in the area, but in addition 18,000 to 20,000 gal. of natural gasoline is being processed per day, and crude oil stabilized.

Connected to the plant are 45 oil wells in the Joe's Lake field and three gas wells in the nearby Spurger field. All are flowing naturally. Approximately 6,000,000 cu. ft. of gas is being taken daily by the plant: 4,000,000 cu. ft. from wells in the Joe's Lake field and 2,000,000 cu. ft. from the Spurger field. Gas from the latter area is used only for pressure maintenance, whereas the gasoline manufactured is stripped from the gas produced from oil from Joe's Lake field wells.

The wells in the Joe's Lake field are producing from the Wilcox sand at an approximate depth of 7700 ft. Tubing pressure is 1200 lb. and wellhead pressure 1600 lb. The wellhead pressure is reduced to 115 lb. at the plant by regulators.

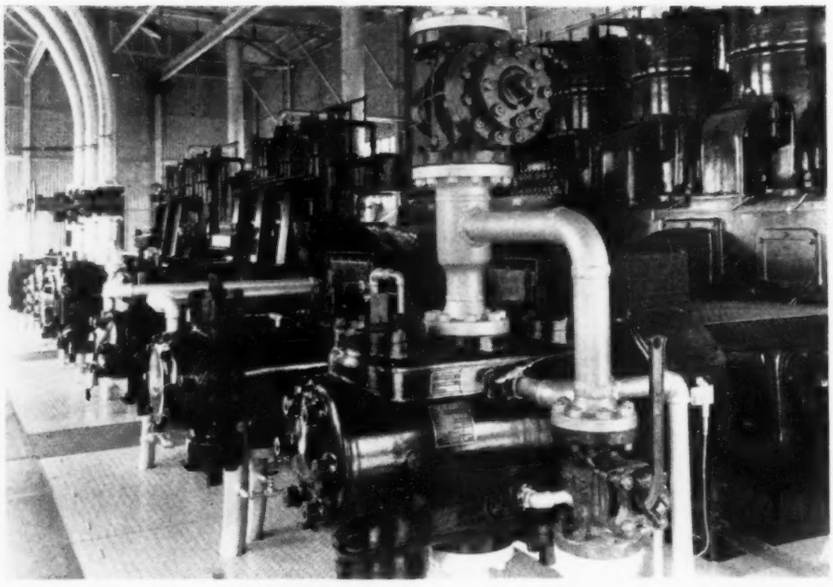
Injection is into a single key well at a pressure of approximately 2700 lb., the gas being returned to the Wilcox sand both through the casing and tubing, the 2½-in. injection line branching to form a Y at the wellhead, one line connecting with the tubing, the other with the casing.

Crude oil received at the plant enters a 130-lb. field-type separator wherein a part of the gas is separated from the oil in the conventional manner. The oil then passes through two small treaters and is heated to eliminate any water that may be present, the water being drained to the sewer line. The oil stream is split and is discharged to two separators of the same type as the first receiving separator. The flow is then to a 2-compartment vacuum tank. Here any remaining gas in solution with the crude oil is flashed and the oil is delivered to seven 1000-bbl. storage tanks as stabilized crude.

Pressure on the upper compartment of the vacuum tank is maintained at 25 lb. per sq. in. gauge and on the lower compartment atmospheric pressure is usually carried, sometimes a slight amount of vacuum.

A part of the gas taken from the top of the vacuum tank passes to an accumulator tank operated at approximately 25-lb. pressure. Gas from the lower compartment of the vacuum tank passes to a scrubber, thence to the No. 1 cylinder of the low-pressure 300-hp. compressor on which the suction pressure is slightly less than atmospheric pressure and discharge is at 25 to 30 lb. gauge. The flow is through cooling coils in the base of the cooling tower, to the accumulator operating at approximately 25 lb. Here it mixes with the gas mentioned above that is received directly from the vacuum tank. The joined gas streams then flow to the No. 2 cylinder of the low-pressure unit and the gas is compressed to 115-120 lb., passing then through cooling coils and to a 123-lb. accumulator where it meets incoming gas from the separators. The gas flow is then through a scrubber to the No. 3 cylinder of the low-pressure compressor.

The total volume of these two gases entering No. 3 cylinder of the low-pressure compressor is controlled by automatic speed regulation. The automatic speed control consists of a pressure controller connected to the intake gas line and operating the diaphragm valve on the governor. Any tendency of the suction pressure of the third



Compressors consist of two 300-hp. and one 500-hp. units

stage to vary causes the speed of the unit to change, thus maintaining a constant third stage suction pressure.

From the third stage, gas is discharged at 350 lb. to a scrubber, thence to another 300-hp. compressor and in two stages the pressure is increased to 2700 lb. at which pressure it goes to the injection well. Between compression stages the gas is cooled and also is passed through an accumulator operated at 800 lb. In effect, the two 300-hp. compressors, therefore, constitute 5-stage compression from 6-lb. absolute initial suction pressure on one unit to 2700-lb. (3500-lb. maximum) discharge pressure on the second unit.

Additional gas (about 2,000,000 cu. ft. per day) for repressuring is brought to the plant from wells in the nearby Spurger gas field. This gas is not processed to strip it of gasoline content. The gas pressure is reduced at the wells by bottom-hole chokes and surface regulators, gas going to the plant at approximately 80-lb. pressure. There, passing directly through the 800-lb. accumulator mentioned, it is compressed by the high-pressure 500-hp. compressor to 2700 lb., and joins the gas flow to the injection well.

Gasoline vapors removed from the gas in the 2-compartment vacuum tank and the several accumulators are sent to a stabilizer and there made into a 26-lb. Reid vapor pressure product. The stabilizer operates at 200-lb. pressure and 225°F. temperature. Discharge is to three 25,000-gal. storage tanks from where the gasoline is measured and pumped by low-clearance reciprocating-type pumps into the crude oil line of American Petroleum Company and transported to American's Silsbee station storage tanks, approximately 15 mi. distant. The blended product is then sold to the Atlantic Pipe Line Company.

Compressor Units

Three compressors have been installed, two 300-hp. and one 500-hp. vertical 2-cycle right-angle gas-engine-driven units. The 300-hp. low-pressure compressor has a 14½-in. cylinder for low-stage compression, an 8-in. cylinder for intermediate-stage compression, and a 9½-in. cylinder for high-stage compression. The 300-hp. high-pressure compressor is equipped with two cylinders, 3⅛ in., and 4⅝ in. in diameter. The 500-hp. compressor is equipped as follows: low stage, 8¼-in. cylinder; intermediate stage, 5⅛-in. cylinder, and high-stage 3½-in. cylinder. All power cylinders are of 14 in. diameter. The 500-hp. unit is not used in the manufacture of gasoline, taking gas direct from the separators, compressing it, and discharging to the injection well.

Because of the loosely consolidated soil at the plant, the three compressors were balanced dynamically to reduce vibration.

Cooling Tower

The cooling tower is of the enclosed, induced-draft type, a single 14-in. fan at the top of the tower providing the suction. Water is circulated over the tower by two turbines driving four centrifugal pumps, each turbine driving two pumps. One unit is used as a standby.

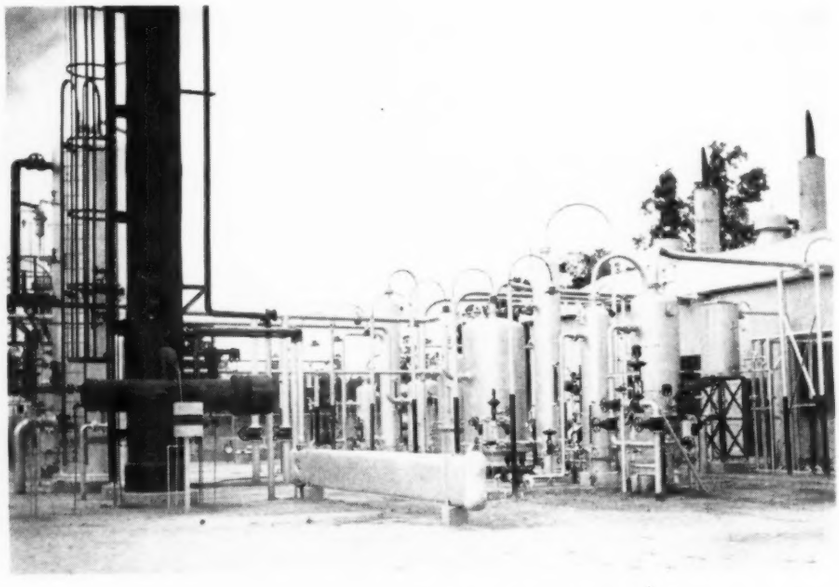
Steam Plant

Steam necessary for the operation of the plant is provided by three 100-hp. oil-field type boilers operated at a working pressure of 200 lb. per sq. in. Steam used to operate the turbines is condensed and returned to the boiler feed tank, which is held at a temperature of 180°F. In this manner a limited amount of makeup water is required.

Water Supply

The water supply is from two deep wells, the flow being into a concrete basin from where it is circulated through a standpipe 35 ft. high to give even pressure on all makeup lines—lines to the boiler-feed tank, cooling tower, and jacket water tanks.

Frick-Reid Supply Corporation was the contractor for construction of the plant.



A part of the processing area

P 624.
P 629.2

Interior of Panhandle Eastern Pipe Line Company's Hansford compressor station

Additional Compressor and Dehydration Facilities on Major Gas Line

PETROLEUM ENGINEER Exclusive Feature

☆ **New 3900-hp. Hansford station and dehydration plant at Sneed are elements in expansion program of Panhandle Eastern Pipe Line Company**

by F. S. Young, Engineer, Panhandle Eastern Pipe Line Company

IN anticipation of new peak demands during the winter of 1941-1942 augmented by increased gas sales in existing markets, Panhandle Eastern Pipe Line Company has recently completed an expansion program consisting of main-line looping and the installation of additional dehydration and compressing facilities. More recently the company has authorized additional work that will result in completely looping the eastern section of the line.

Engineering studies of main-line capacity requirements indicated the need for a natural-gas dehydration plant in the Panhandle field at Sneed station, Texas, the terminus of the company's main field gathering line, in addition to a 3900-hp. compressor station midway between Sneed station and Liberal station, situated a few miles north of the Oklahoma-Kansas state line.

Dehydration Plant

Increased volumes of gas and higher discharge pressures at Sneed station during the last two years had seriously increased the deposition from the gas of water vapors in globular form on the interior walls of the main gas line leading from the station. This condition is particularly serious during winter operation as hydrates tend to form in the presence of the water, resulting in line freezes and consequent excessive pressure drops, interrupting service unless immediately corrected.

As a remedy for this unfavorable condition, a new type dehydration plant was installed to depress the dew point of the gas lower than the minimum line temperature, thus avoiding deposition of liquid water and resulting hydrate obstructions.

The plant consists primarily of three vessels known as contactor-separators, a circulating medium of diethylene glycol, circulating pumps to circulate the medium, a fractionating column, and controls for automatic plant operation. A steam plant is the source of heat required for rectification of spent glycol and also supplies the power for operating the circulating pumps.

The contactor-separators are designed to allow compressed natural gas to come into surface contact with the diethylene glycol, a chemical that has a marked affinity for water. These contactor-separators contain an internal baffle arrangement such as might be encountered in a steam trap and are designed with a convex baffle at the top of the vessel near the gas inlet. As the gas whirls into the vessels, glycol is injected into the gas stream. The gas-glycol mixture strikes the convex head where it diverges and separates into

Contactor-separators at left, float tank in center, and vent tank at right—dehydration plant at Sneed compressor station

dried gas and the water-laden glycol accompanied by a small amount of gasoline, is released from the inflowing gas. The dried gas flows from the contactor-separator, discharging into the main line. The water-diluted glycol-gasoline mixture flows over the contact head and thence into the bottom of the vessel from which it is automatically drained to enter the process of separating the water from the glycol.

The liquid mixture flows from the contactor-separators into a float tank equipped with automatic floats to control the liquid level in the contactors. When the mixture rises to a designated level in the float tank, a liquid-level float control opens a motorvalve and the liquid is forced from the float tank into a separator and vent tank. The separator and vent tank serves as a means of separating the gasoline and other condensed hydrocarbons from the water-glycol mixture. Here again, when the liquid level rises to a predetermined point, the condensed gasoline is drained off the surface of the glycol-water mixture through a motor valve actuated by float control. The water-laden glycol is forced from the bottom of the separator tank through a 2-in. line to the rectifying column under approximately 15-lb. pressure. Volatile vapors are vented automatically to the atmosphere when the water-laden glycol level drops to the level at which the liquid operates a float-controlled vent valve.

Before entering the rectifying column the cold glycol-water mixture is preheated in a bank of heat exchangers, in which heat is transferred to the cold mixture from the hot glycol coming from the bottom of the column. From the exchangers the heated water-laden glycol enters the rectifier, in which the water separating process begins.

The liquid enters approximately halfway up the side of the column and then descends slowly by gravity over a series of bubble trays to the bottom tray. From this point the liquid is piped directly to a reboiler in which it is heated to 270°F. (132°C.) to remove the entrained water, and is then forced back to the bottom of the still. Steam and glycol vapors released from the boiling liquid ascend the column from tray to tray through the bubble caps. This arrangement requires the mixed vapors to pass through the hot condensed liquid that is flowing downward over the trays, as mentioned above. The glycol vapor tends to join the downflowing liquid and the water contained in the liquid tends to join the upflowing vapors, as steam, thus effecting a concentration of the glycol. The steam approaches the top of the vessel nearly free of glycol vapor, while the glycol flows downward to the reboiler almost free of its water content.

To prevent glycol vapors being carried-over with the steam to the boiler feed tank, water as a reflux is piped into the top tray to maintain a constant temperature differential between the top and the bottom of the vessel. As the reflux descends in the column its temperature increases, further condensing or enriching the glycol vapors by the evaporation of the water. Steam and glycol vapors from the heated water-glycol solution that form as the solution first enters the column bubble up through the reflux and are fractionated in the same manner as the vapors ascending from the bottom of the column.

A liquid-level-controlled motor valve governs the flow of hot glycol from the bottom of the still through the heat exchangers in which the incoming water-laden glycol is preheated.

From the exchangers the re-concentrated glycol enters a surge tank that floats on the suction of the steam-driven glycol pumps. The pumps discharge the glycol into the top of the contactor-separators to again begin the cycle of dehydration.

The construction contract for the dehydration plant was awarded to the Fluor Corporation, Ltd., of Los Angeles, California.

Hansford Station

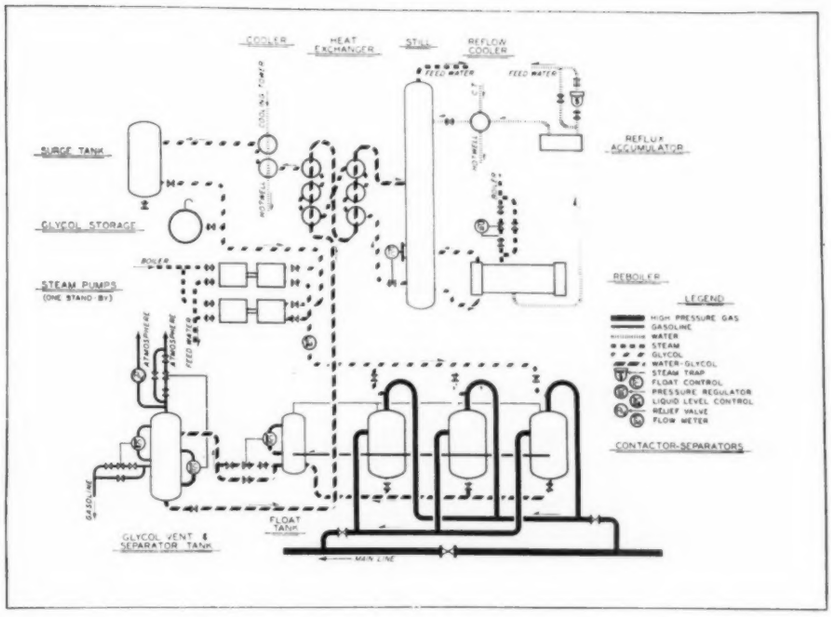
The 3900-hp. compressor station, in Hansford County, Texas, about two miles south of the Oklahoma state line, is of most modern design. Main compressor units consist of twin single-stage compressor cylinders direct-connected to 650-hp. angle-type gas engines. An important feature of this type of installation is the ability to operate the compressors equally well at any speed between full and half, and at any load between full and no load, resulting in a station possessing maximum flexibility in engine speed and load regulation. This characteristic is particularly well adapted to Hansford station as it was designed primarily as a booster on the main transmission line.

The plant consists principally of a main building, auxiliary building, meter house, office building, elevated water tank, shell-and-tube jacket-water cooling units, atmospheric cooling tower, gas coolers, oil storage tank, and starting-air receivers. In addition to the buildings mentioned, a camp of 7 houses and a 12-car garage are situated on the plant site.

The main building, auxiliary building, and meter house are structural-steel frames covered with corrugated asbestos siding and roofing. The steel frames were especially designed to carry maximum concentrated crane loads superimposed on the bottom chord of the trusses. The structure is designed for a 300-lb. per sq. ft. loading, to facilitate handling of heavy parts when repairs become necessary. A continuous 8-in. trolley beam extends over each line of power cylinders as a track for two spur-geared hand-operated chain hoists. All trusses were shop-riveted and shipped to the job where they were field-riveted to the columns.

The main building and auxiliary building foundation walls are of reinforced concrete, extending from well below frost line to 3 ft. above finished floor level. Expansion and contraction of the wall sections were provided for

Flow diagram of dehydration plant, Sneed compressor station



by installing 1-in. vertical joints at 50-ft. intervals. A coping and splash board was poured between the top of the wall and the bottom of the sash and the corrugated asbestos panels.

Concrete was proportioned, as nearly as practicable, to obtain a 1-2-4 mix for foundations and wall sections; a 1-2½-5 mix was specified for footings or mass concrete. Aggregate was carefully selected, graded and washed gravel, shipped to the job. Sand obtained locally was used throughout, each load being carefully checked to prevent inclusion of foreign material. All floor surfaces and portions of the engine and equipment foundations above the floor line are of finished black concrete dressed and waxed as a protection from oil and grease. Exposed surfaces of foundations and building walls are ground smooth with carborundum stones.

The main compressor units consist of six 650-hp., 300-r.p.m., vertical V-type, 8-cylinder, 4-cycle, single-acting gas engines each direct-connected to twin horizontal, crosshead-type, double-acting compressors having a 10⅝-in. bore and 15-in. stroke. Compressor cylinders are designed to compress a maximum of 160,000,000 cu. ft. of gas per day at 450 lb. per sq. in. discharge and a 1.5 compression ratio. Capacity of each machine can be maintained within the range of 275- to 325-lb. suction pressure and 400- to 450-lb. discharge with maximum efficiency. Compressor cylinders are designed of such a diameter that under maximum loading conditions the rated horsepower of the engine will not be overloaded more than 10 percent.

Power cylinders have a 14½-in. bore and 18-in. stroke and are of the wet removable liner type. The liners are clamped at the top and free to expand at the bottom. They tend to keep a more nearly perfect shape as they are not distorted by head or load stresses, thus reducing wear of rings, pistons, and cylinders. Disregarding other qualities the liners are built of high-grade material to withstand heat, wear, and cylinder-wall stresses. Power cylinder walls are lubricated by splash from the crankcase oil. Oil consumption is kept at a minimum by control rings on the pistons, maintaining a proper film of oil on the wearing surfaces. A full force-feed type lubricating system provides lubrication to all bearings. A separate force-feed lubricator (with individual adjustable sight-feeds) supplies each compressor cylinder and stuffing box.

Main units are arranged back to back with suction headers and discharge headers extending along both sides of the main building. This type of installation provides a maximum of horsepower in a minimum of floor space. Engines were spaced so that suction and discharge lines from the compressors on opposite sides of the building were symmetrical. These lines are equipped with expansion bends securely anchored in such a manner that vibration is dampened without interfering with expansion and contraction of the pipe due to changes in gas temperature.

All machines are equipped with filters on the free air combustion intake to combat the severe dust conditions of the Texas Panhandle. To protect the filter from damage due to backfiring, an automatic relief valve was supplied in each air filter riser. A special airtight felt gasket acts as a valve seat to prevent harmful dust and sand particles from being carried by the free air into the interior of the engines.

Exhaust mufflers are of the vertical air-cooled type, projecting through the roof. Each stack is enclosed in a steel casing 6 in. greater in diameter than that of the exhaust pipe. The mufflers are well designed with low back-pressure characteristics that minimize exhaust noises.

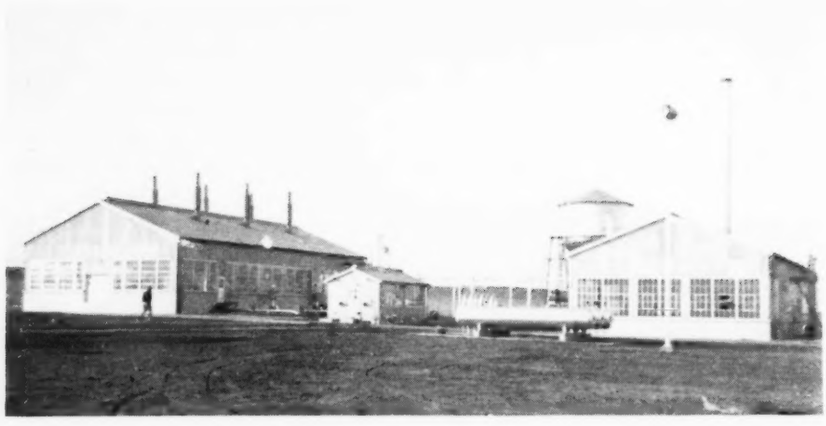
The fuel system consists of a sensitive low-pressure regulator and a constant-quantity mixing valve that automatically maintains the correct air-gas mixture at designated speeds and loads.

Automatic mercoid-controlled safety devices on each unit will shut the engines down in case of failure of the governor, oil-circulating system, or the water-circulating system.

Elevated walkways of welded grating on structural steel frames provide an operating and working floor around all machines. The grating is continuous down the center for the entire length of the building between the two rows of engines, with individual catwalks extending between and to the front of the units.

Auxiliary building equipment consists of two 125-kw. electric power generating units, one 30-kw. standby generating unit, switch gear cubicle, one 30-hp. boiler for space heating, five centrifugal water pumps, two V-type air-cooled air compressors, water softener, oil centrifuge, motor-driven drill press, and tool grinder. Water pumps for jacket water and cooling tower service are situated in a pump pit in one end of the building. A totally enclosed wash room and stock room with prefabricated walls and partitions occupies the opposite end of the building. Generating units, power cubicle, boiler, air compressors, and other auxiliary equipment are installed in the central portion of the building, all adequately spaced for easy operation and maintenance.

Cooling water is obtained from two deep wells spaced 300 ft. apart, each well producing more than 300 gal. per min. when tested. The wells were drilled 20-in. in diameter and reamed to 36-in. in diameter through the water-bearing stratum. A bronze screen was installed opposite the water bearing formation, connected to a casing extending to ground level. Selected gravel was forced between the casing and the drilled hole to create gravel walls for the wells. A turbine pump, rated at 300 gal. per min. was installed unhoused on a concrete slab over each well. A 30-ft. steel derrick was erected



General view of Hansford station showing main and auxiliary buildings

over each well to facilitate repairs on pumps or cleanout operations.

A closed jacket-water system, instead of the usual open type, was designed for jacket-water cooling. In an open system the prevailing dust conditions of the Texas Panhandle tend to cause heavy mud deposits to form around cylinder walls due to excessive amounts of dust and dirt absorbed by the jacket water when an atmospheric (open) tower is used for cooling. The closed-type system will eliminate the clogging of water passages around cylinder walls, thereby lessening the chances of scored cylinders and subsequent expensive engine repairs.

Cooling is accomplished indirectly by pumping treated hot water from the engines through shell-and-tube intercoolers. Hot jacket water circulates through the shell of the cooler and its heat is transferred to cold raw water flowing through the tubes. The water is then pumped through the engine jackets and emptied into a surge tank, to which the suction of the jacket-water pump is connected, to complete the cycle. Individual air relief valves are placed immediately above each engine in the return lines to the surge tank, to bleed any air that might become entrained in the engine water jacket causing dangerous "hot spots" in the cooling system.

Two surge tanks are required on this system to insure uniform flow conditions, instrumental in a constant temperature control. A 48-in. diameter tank was installed for the main units and a 22-in. diameter tank for the auxiliary generating units. Treated make-up water is pumped into the system automatically as required, a float control switch holding the water level at the top of the large surge tank, starting and stopping a centrifugal pump that discharges water through a water-softening plant and thence into the system.

The raw water, heated as it is pumped counterflow to the jacket-water, travels from the exchangers to the top of the cooling tower and is cooled as it sprays down through the tower sections. As the cool water nears the bottom of the tower it is collected and discharged over gas coolers above the basin, cooling the hot compressed gas discharged from the engines. From the basin the water drains to the suction of two centrifugal pumps that discharge directly into the water cooling units.

A 75,000-gal. elevated water tank floats on the discharge of the cooling tower pumps, insuring steady flow conditions as well as a reserve water supply. The tower is connected by a 10-in. bypass into the closed system. In case of failure of the jacket water pumps, the bypass can be opened, allowing the plant to operate for a limited time from elevated storage.

An important feature in the gas piping design was the determination of adequate sized lines throughout the plant, especially to and from the compressors, in order to reduce pressure drop to a minimum, particularly when operating the plant at low suction pressures. Pipe bends were prefabricated, insuring smooth radial turns having only slight restriction to gas flow. All lines are of solid-welded construction, each weld being backed by a chill ring and reinforced with standard welding saddles. Flanges for high-pressure gas and air service are of series 30 forged steel, vanstone type.

Gas enters the station through a 22-in. suction line and is then divided between two 16-in. headers, one on each side of the main building. From these headers the gas is fed through 8-in. lines directly into the compressor cylinders, where it is compressed and discharged through 8-in. lines into 16-in. discharge headers outside the building, one on each side. These headers are connected to a larger header at the cooling tower. After the gas flows through the cooling coils in the tower, it enters a 22-in. discharge line, which conveys the compressed gas to the main line.

Piping for gas, water, air, steam, oil, and drain lines is A.P.I. grade B, seamless line pipe in 16-in. and larger sizes and A.P.I. grade A, seamless line pipe in smaller sizes. All piping so far as practicable was shop-fabricated and shipped to the job ready for erection. Welded piping for gas service was subjected to 750 lb. per sq. in. hydrostatic test before being placed in operation.

Starting air is supplied by two V-type, two-stage, air-cooled compressors, each having a rated displacement of 41 cu. ft. per min. at atmospheric intake pressure and 250 lb. per sq. in. discharge. One machine is driven by an electric motor equipped with automatic start-and-stop control. The second machine is a gas-engine-driven unit installed as a standby. Each compressor delivers air into three electric-welded, stress-relieved, air receivers that float on the compressed-air discharge line.

Fuel gas is supplied to the me building through 3-in. lines from either the plant suction or discharge, insuring uninterrupted service. Here the gas is reduced to a pressure of only a few ounces by three stages of pressure regulation: (1) 450 to 175 lb.; (2) 175 to 50 lb., and (3) from 50 lb. to the few ounces of pressure required. The gas flows from the meter house to separate headers in the compressor building where the pressure is again reduced to engine requirements by separate pressure regulators that direct the gas through quick-acting valves to the fuel-mixing chambers.

The gas is metered between the intermediate and low-pressure regulators by an orifice meter installed in a meter run equipped with straightening vanes on the upstream side. Fuel gas is fed to the headers in the main building through a 12-in. line and supplied to the auxiliary building through a 6-in. line.

The 4000-gal. lubricating oil storage tank is installed horizontally, directly beneath the footing of the main building wall. One end of the tank projects 3 ft. within and under the building floor. A 2-in. suction line, with foot valve, extends from the tank vertically to a dispensing hand pump on the main building floor. This feature places the tank as close as possible to the pump, thereby providing a short suction that insures positive pump displacement with good delivery.

Hansford station was constructed by Stearns-Roger Manufacturing Company, Denver, Colorado. The camp was built by L. O. Stocker Company, St. Louis Missouri.

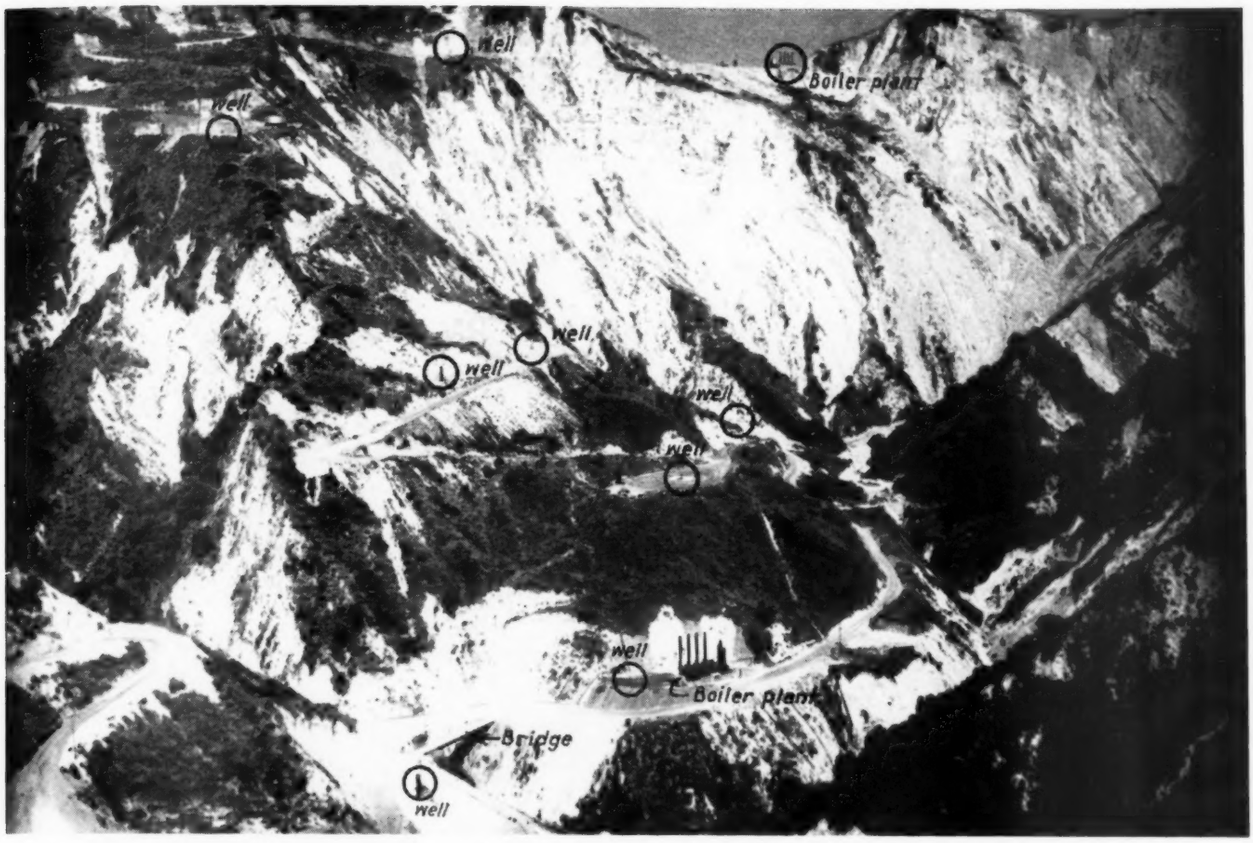


Fig. 1. General view of the amphitheatre in the San Miguelito Field, California

Development of Mountainous California Field

PETROLEUM ENGINEER Exclusive Feature

Directional drilling used to advantage to obtain proper spacing in the productive zone

by Wallace A. Sawdon
Pacific Coast and Foreign Editor

ALONG the coast of Southern California are fields that present many diverse development problems. Within a very few miles of each other are productive areas in which the structures lie partly below water beyond the shore line of the Pacific Ocean; in other fields the oil reservoir may underlie the Coast Range that rises abruptly from the sea. In both, the use of directional drilling has been the means of obtaining an economical well spacing in the productive zone. The surface problems, however, are entirely different and in the mountainous regions the transportation of equipment in and production out not only requires careful planning and great initial expense but necessitates constant maintenance of roads and pipe lines throughout the life of the field. Probably the most interesting area from a topographical standpoint is the San Miguelito field of the Continental Oil Company situated approximately 5 miles west of Ventura.

Within the limits of this field is a deep amphitheatre with steep sloping walls surrounded, except for a canyon outlet, by a rim 1000 ft. or more above sea level. Inside this amphitheatre 10 wells have already been drilled, 8 of which may be seen in the accompanying photograph, Fig. 1. These are all flowing wells and the derricks have been removed. The other two wells not shown are situated in the canyon to the left of the bridge, which can be seen in the lower left corner of the picture and which is shown more clearly at the left in Fig. 2. The approach to the amphitheatre is by a

Fig. 2. Bridge and boiler plant in bowl of the amphitheatre—producing well in foreground

mountain road winding up from the shore of the Pacific to a saddle approximately 1000 ft. above. Fig. 1 was taken facing slightly east of north; looking backward, the photographer could see the ocean 1000 ft. below.

Other wells in the field are located outside the rim of the amphitheatre and all are flowing except one into which residue gas is being injected at the present time. Currently the wells now completed are producing approximately 2500 bbl. per day under curtailment but the potential is probably more than ten times that amount.

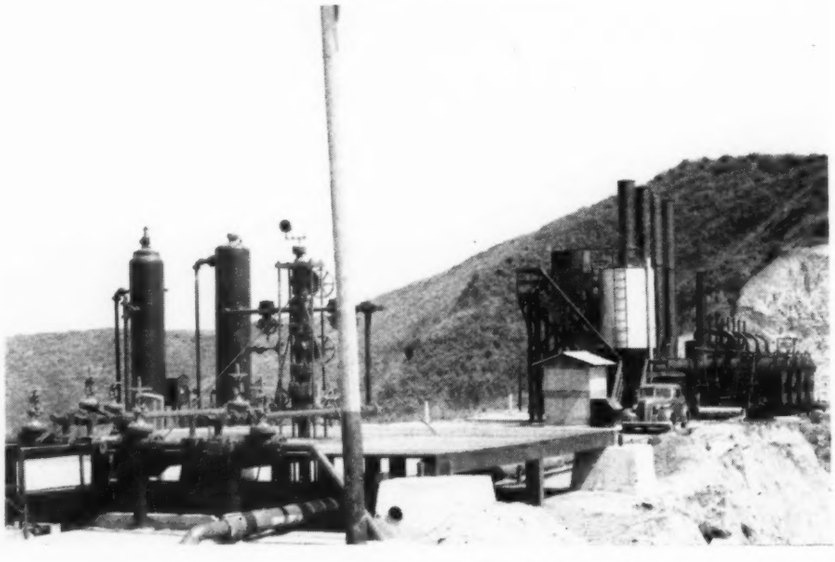
After the discovery well, located near the top of the hills, was completed in 1931 plans were made for developing the amphitheatre, which quite evidently lay well up the structure. Several plans for hauling in equipment were considered, among which was the construction of a tramway; but it was finally decided that the best way would be to construct a road over the mountains rather than through the canyon connecting the amphitheatre and the ocean, thus maintaining one entrance to the lease instead of two. This also meant the building of roads into the amphitheatre where the sides slope much more steeply than on the outside. The road to the rim would, of course, serve the other wells in the field and would have been necessary for their development. Surface locations directly over the desired locations in the producing sand were not feasible in all cases for wells both within and without the amphitheatre; but as directional drilling could be utilized to obtain proper spacing on the sand the well sites were chosen by economic determinations based on various factors including road construction, available space for drilling operations, and necessary horizontal drift from the site selected to the position desired on the sand.

There are now 7.5 miles of road servicing the San Miguelito field. Of this distance, 3.5 miles are from the company's office by the ocean to the rim of the amphitheatre, 2.5 miles lie within the amphitheatre, and 1.5 miles extend to the other wells from the juncture at the rim. The bridge is of the deck steel type 106 ft. in length by 12 ft. wide. This crosses the main drainage course and is 65 ft. above the bottom of the canyon.

Due to the soft character of some parts of the slopes the runoff of water during the rainy season is sometimes a serious problem. Culverts fully adequate for the amount of water have been installed but it has been found that brush and undergrowth as well as great quantities of formation debris will often clog the culverts and cause serious damage to roads. Unfortunately it is impossible to anticipate the places where slides will occur causing the uprooting of trees or disintegration of surface formations. It takes heavy and prolonged rains to do any serious damage, however, as the drainage system installed is able to handle normal, or even somewhat excessive, rainfall. The unusual rainy season of 1940-41 caused considerable erosion and settling of earthen embankments.

All wells in the amphitheatre were drilled with steam supplied by the battery of boilers, which can be seen near

Fig. 3. Closeup of boiler plant situated on rim of amphitheatre—producing well in foreground



PETROLEUM ENGINEER EDITION

BAASH ROSS News

BAASH-ROSS TOOL COMPANY, LOS ANGELES 11, U.S.A. — N. NEW YORK

A MONTHLY BULLETIN COVERING NEWS OF EQUIPMENT AND OPERATIONS IN THE PETROLEUM INDUSTRY

WHAT TO LOOK FOR IN DRILL COLLARS ...AND HOW TO BE SURE OF GETTING IT

Many Things Influence Drill Collar Performance All Must Be Considered!

Did you ever stop to consider the *many* important functions a drill collar must perform?

It adds weight just above the bit—yes. But it also acts as a "flywheel" for your entire drilling string, keeping the bit on the job making hole... steadying the string to s-m-o-o-t-h, even rotation... absorbing the sudden impact loads of cutting the formation... and at the same time, resisting the severe abrasive action of whirling against the fresh-cut walls of the hole.

That's why *balanced* design is the important thing to look for in your drill collars... the *right* properties incorporated into the steel combined with the *right* methods of machining and finishing.

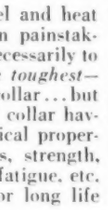
Undoubtedly the best known drill collars in the oil industry are the famous Baash-Ross "Trubore" Drill Collars... famous because, through years of specialization in this field, Baash-Ross has learned how best to put *balanced* performance into every drill collar.

For one thing, the steel and heat treatment used have been painstakingly worked out... not necessarily to give the *hardest*—nor the *toughest*—nor the *strongest* drill collar... but rather, to produce a drill collar having *all* the required physical properties—toughness, hardness, strength, resistance to impact and fatigue, etc. ...in the best *balance* for long life and dependable operation.

That's an important point to remember. Because a drill collar that has too much of one property is apt to have too *little* of another... and under the bruising beating that a drill collar takes, just *one* weak point is enough to put it on the skids.

So *balanced* physical properties in the steel is one of the important factors you get in every "Trubore" Drill Collar. Then comes the workmanship.

▶ Where ordinary drill collars often get into trouble is when the circulation hole is bored. This hole is bored from each end to meet in the middle. If the bores do not meet on the nose, a "dog-leg" something like this ☞ is left at the center. This is not only sufficient, in itself, to make the drill collar run unevenly, but the trouble gets worse with use. This "dog-leg" causes turbulence in the flow of the drilling fluid, setting up "eddy currents" that eat out and enlarge the hole at this point—throwing the collar—and with it, the drill string—into a bad state of the "jitters." Not only that, but did you ever try to get a retractable core barrel or survey instrument through a dog-legged drill collar? Try it!



You'll never find this trouble in Baash-Ross "Trubore" Collars. The circulation hole is held to tolerances so close that special boring equipment has been developed to meet them. And then the hole is *double-checked* by passing a ten foot test bar, not more than ⅛" smaller than the bore, through from end to end. It must pass freely at all points *without binding!*

Add to this the fact that the joints are aligned so accurately that their projected axis with respect to the nominal axis of the product does not deviate more than ½" *in 40 feet*... and the straightness does not deviate more than ⅛" from true at any point *over the entire length*... and you have some idea of the *all around* balance that makes Baash-Ross "Trubores" the pick of the industry.

These things are hard to *see* in a drill collar, but there's an easy way to KNOW you are getting them—specify *Baash-Ross "Trubore Drill Collars!*

TO THE LAYMEN, a Drill Collar looks like a pretty simple thing... but the truth of the matter is that the making of a good Drill Collar is one of the most exact sciences we know of. For example, here are a few of the many important qualities that Baash-Ross builds into *every* "Trubore" Drill Collar...

BALANCE—To insure smooth running at all speeds, the circulation hole in every "Trubore" Drill Collar is drilled with equipment specially developed by Baash-Ross. The standard tolerance for the bore is plus $\frac{1}{32}$", *minus zero* and the bore is so drilled that the wall thickness does not deviate from the theoretical correct, when checked by survey, by more than ± ¼" in 40 *feet!*

ACCURATE ALIGNMENT — Since Drill collars won't bend, any misalignment in the joints causes a slight "elbow" where collars join. As the string rotates, each elbow bends—first one way, then the other—causing severe bending stresses in the pins. *But not in Baash-Ross Drill Collars.* We survey *every* joint to insure that the projected axis of the joint does not deviate from the nominal axis of the collar by more than ½" in 40 feet!

TOUGHNESS — In driving the bit, the Drill Collar is constantly subjected to severe impact and torsional strains as the rotational resistance of the bit fluctuates—high one minute, low the next. Careful selection of alloy steels plus two full length heat-treatments and a third localized heat-treatment, insure the correct amount of *toughness* in every B-R Drill Collar.

HARDNESS — The Drill Collar, following as it does right behind the bit, is constantly rotating against the highly abrasive, fresh-cut walls of the hole where no protective mud-cake has been built up. In heat-treating "Trubore" Drill Collars, special precautions are taken to insure plenty of surface *hardness* to resist this abrasive action.

FOR MAXIMUM ALL-AROUND PERFORMANCE, IT'S BAASH-ROSS "TRUBORES"!

Fishing Tips

STUCK DRILL PIPE

SAND AND CUTTINGS THAT FORM BRIDGES *in the hole probably account for most cases of stuck drill pipe. Moral: keep the mud, mud pits and shaker in proper condition to carry ALL sand and cuttings out of the hole and KEEP them out.*

BAASH-ROSS

ANOTHER GOOD RULE TO AVOID STICKING PIPE *is to pull bit off bottom BEFORE shutting the pumps down. In addition, it's wise to keep the hole filled with mud while making a trip, thus maintaining constant wall pressure to prevent cavings.*

BAASH-ROSS

IF TOOLS STICK EASILY IN THE FORMATIONS YOU DRILL, use a Baash-Ross Bumper Sub in the string. Simply by straight raising or lowering of the string it will jar up or down, whichever's necessary. Simple and rugged, it's a genuine SAFETY tool to run above bits or reamers in sticky digging... and can save a costly fishing job.

BAASH-ROSS

WHEN CIRCULATION THROUGH STUCK PIPE CAN BE OBTAINED, intermittent stopping and starting of pumps with tension held on the pipe will frequently free it. "Water hammer," accomplished by pinching the pump suction, will induce vibration which is often successful in loosening pipe. But remember—slacking off tension during these operations can stick the pipe even tighter!

BAASH-ROSS

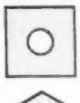
A SAFETY JOINT CAN BE THE DRILLER'S BEST FRIEND when he's drilling through caving or heaving formations. Installed in the string just above the trouble-some sand, it permits quick and easy disconnection of the string at that point should the pipe stick. *But ... to make sure the joint you use is as safe as any part of your drilling string, be certain you call for a Baash-Ross Autolock Safety Joint!*

IMPORTANT FACTS ABOUT KELLYS!

It's only logical that the subject of Drill Collars should bring up talk about the other end of your drill string—the *Kelly* end.

To be certain you're getting the best running mate for your string of "Trubore" Drill Collars be sure to specify *Baash-Ross "Trubore" Kellys* ...because into these Kellys go the same skill, the same painstaking precision, the same careful selection of materials and control of heat-treatment that have made the "Trubore" name famous wherever men drill for oil.

And from Baash-Ross you can get whatever type of Kelly you prefer...



SQUARE—the old "standby" for general drilling conditions.

HEXAGONAL—the best kelly you can buy for all-around drilling efficiency.

OCTAGONAL—a popular kelly for use with packers when drilling under pressure.

As we say, Baash-Ross can supply you with whatever type of kelly you prefer... but if you should ask *us* for a recommendation as to which of the three kellys is best for modern drilling operations—*which will give you the most performance for your dollar* ...there is only one answer we can honestly make...

The Hexagonal Kelly—by an overwhelming margin!

Here is the "balance sheet" on comparable sizes of the Hexagonal vs. the Square Kelly.

The Hexagonal Kelly has...

BETTER BALANCE - because it is accurately machined - not forged - to shape.

28% MORE STRENGTH IN TORSION - an important advantage in rotating the drill string.

1.8% MORE STRENGTH IN TENSION - an important advantage in supporting the string.

23% MORE RESISTANCE TO BENDING - a big point in maintaining straightness.

48% MORE CIRCULATION AREA - of vital importance with modern high-volume pumps.

THEN REMEMBER THIS: You can use the hex for *every* type of drilling operation... BOTH regular and pressure work —*without change!*

Regardless of the *type* of kelly you plan to buy, there is a Baash-Ross "Trubore" to meet your requirements. But before you buy *any* kelly, investigate the Baash-Ross HEXAGONAL. Your nearest Baash-Ross representative has complete details..., or write us direct!

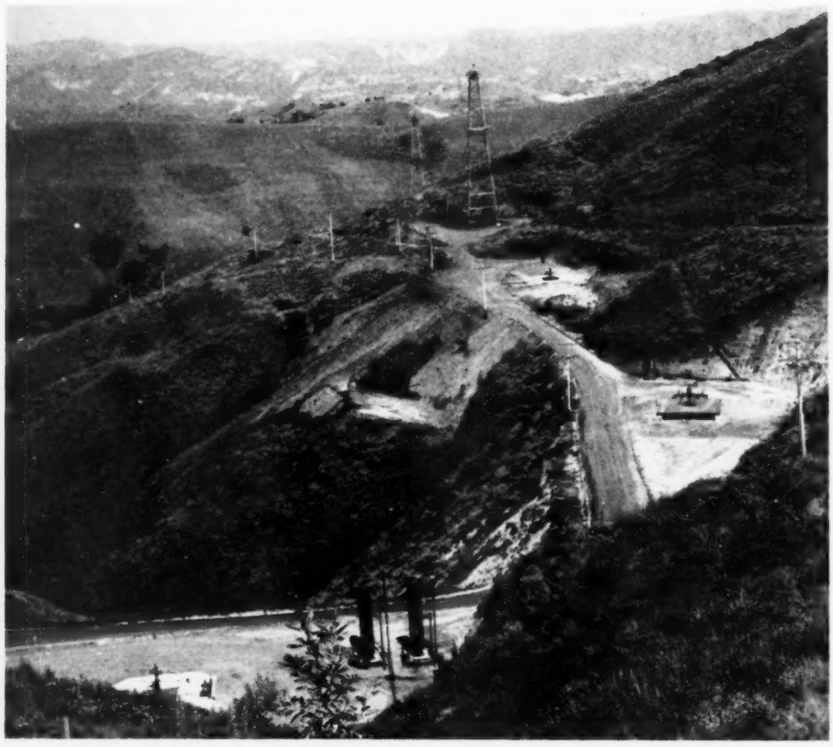


Fig. 4. Wells adjacent to boiler plant were drilled by steam supplied through insulated 6-in. lines. Note neat appearance of the improvements

the bottom of Fig. 1 and to the right in Fig. 2. At one time when two wells were drilling at once the battery consisted of six boilers. Wells beyond the north and northwest rim were, and are being, drilled with steam from the boilers, which can be seen through the saddle at the upper edge of Fig. 1. This battery, with one of the wells, is shown in Fig. 3. In Fig. 4 are shown some of the wells to the north that were drilled with steam from this battery. The derricks are still in place over two of the wells recently completed. At present the battery is supplying steam to a well drilling at a location to the left of the well that can be seen at the lower left corner of Fig. 4.

Steam is piped from the central boiler plants to the drilling wells through insulated 6-in. lines. The longest of these lines used to date has been 1980 ft. Other wells to the west and southwest of the amphitheatre were drilled with boilers installed at the well in the more conventional manner.

Production from most of the wells goes through a high-pressure separator placed at the well as shown in Fig. 2. The pressure at the trap slightly exceeds 450 lb. per sq. in. The oil then goes by pipe line to low-pressure separators situated near the storage tanks at sea level between the ocean and the mountains. After passing through the low-pressure traps at 35 lb. per sq. in. the oil receives a third stage separation at atmospheric pressure before going to the storage tanks. At some of the wells such as the one shown in Fig. 3, which is at a high point, the production goes through both high and low separators before being piped to sea level.

The gas is processed by a natural gasoline plant of the Western States Gasoline Corporation situated adjacent to Continental Oil Company's storage tanks between the ocean and the mountains. A back pressure of 450 lb. per sq. in. is maintained on the high-pressure gas lines from the field and gas is taken from the low-pressure traps at 35 lb. per sq. in. A slight vacuum is maintained on the third-stage separation gas, which is then boosted to the required pressure for low-pressure absorption.

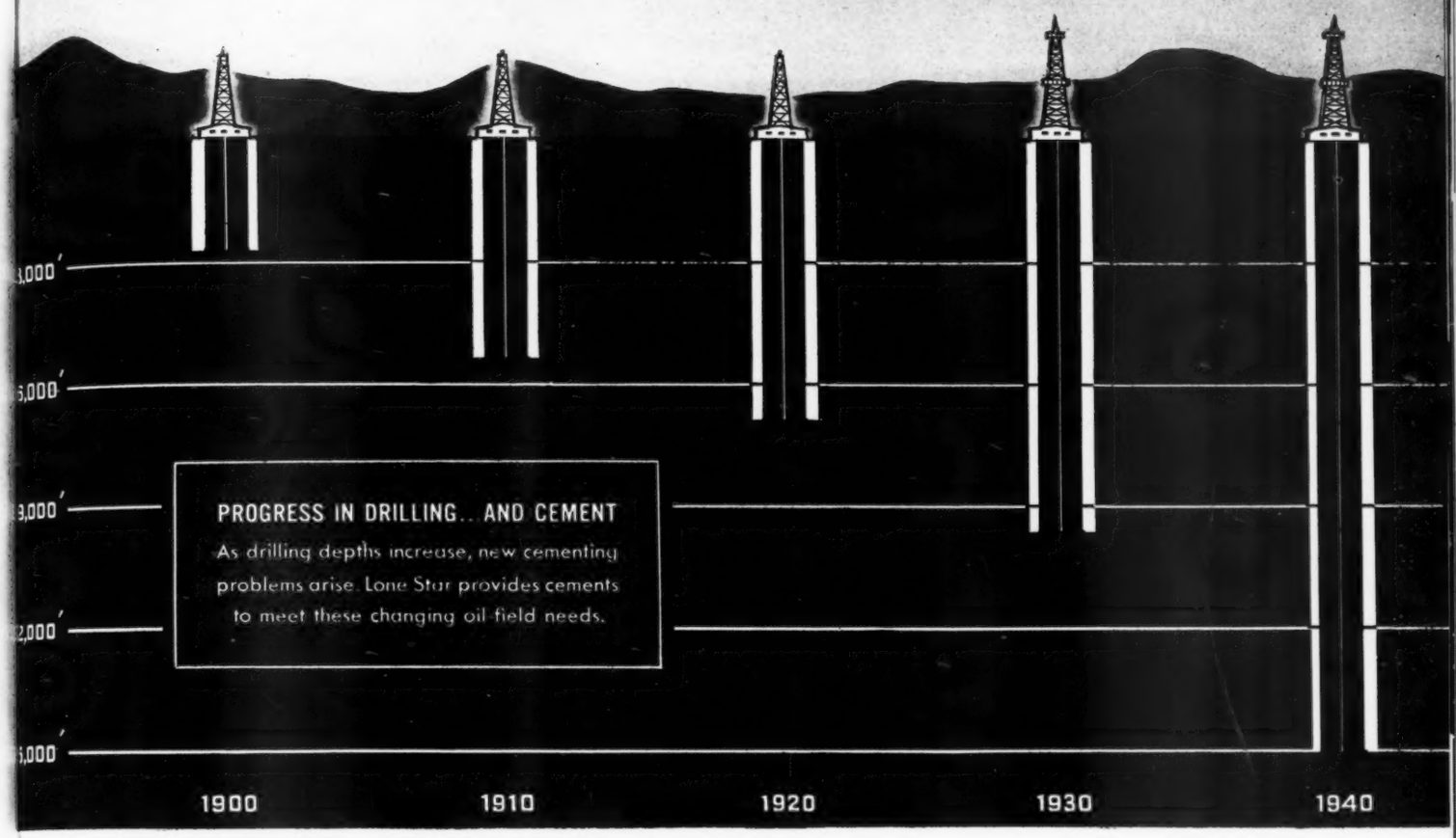
Oil from the wells in the amphitheatre is piped down the canyon shown to the right of Fig. 1. A 3-in. line is fully adequate for the amount of oil allowed by current curtailment. The gas is piped up the side of the amphitheatre where it joins the gas from the other wells and is taken around the rim and down the side of the mountain to the gas plant. Lines going up the steep slopes have to be anchored at intervals to prevent contraction breaking the line. Ordinary methods of providing for expansion will not suffice under the circumstances as the lines cannot readily slide along the ground as is the case where they are laid on level, or comparatively level, ground.

Sections of lines sometimes have to be relaid because of landslides. This usually happens only during a severe rainstorm.

The surface elevations of wells in the San Miguelito field vary from 260 to 1000 ft. above sea level. One well recently completed was at a surface elevation of 842 ft. and was completed at a depth of 7008 ft. The surface string consisted of 13⅜-in. casing cemented at 996 ft. A string of 7-in. casing was cemented above the producing sand and a 4¾-in. perforated liner hung from its bottom at a depth of 6894 ft. All wells in the field flow through tubing and in this well 2½-in. was set at a depth of 6499 ft. The initial production was at a rate of 2522 bbl. per day of 29.7 deg. A.P.I. oil with 2,300,000 cu. ft. of gas.

All wells in the field have been accurately surveyed and after plotting their positions on the sand subsequent wells have been drilled to provide proper spacing in the productive zone. Some of the wells have been drilled vertically but many have had to be drilled with direction control to reach the desired position on the sand from locations that had to be made some distance away horizontally because the topography prevented vertical locations being made. In the development of ocean fields vertical locations can be made but wells are directionally drilled for economic reasons alone; in developing a mountainous field such as San Miguelito directional drilling is resorted to not only for economic reasons but also because there is no other way of properly spacing the wells in the productive zone.

As Oil Wells Go Deeper and Deeper—



Lone Star Meets Changing Oil-Field Needs

Drilling depths have doubled in a little over a decade. That points to rapid progress in drilling and cementing methods—and in oil-well cement.

Through continuing research, based upon close contact with problems at the rig, Lone Star cements keep abreast of drilling developments. 'Starcor' . . . 'Incor' . . . Lone Star—each fills a specific need. Now Lone Star offers 'Texcor' Deep Oil-Well Cement.

'Texcor' was developed for cementing the deepest wells, at today's highest temperatures—or tomorrow's. Mixed with 40% water, 'Texcor' is pumpable *in excess of 8 hours* at 200° F.—a safety factor greater than ever before. High strengths, too—over 5,000 lbs. per sq. in. in 24 hours, over 6,000 lbs. in 48 hours, at 200° F.

Low initial viscosity, easy pumpability in heavy slurries, low pump pressures—greater density of hardened cement.

Lone Star offers Oil Men four great cements to choose from: 'Texcor'† for deepest wells . . . 'Starcor'* for deep wells . . . 'Incor'* for wells of moderate depth . . . Lone Star for all-around oil-field use. Select the cement to fit the job. Lone Star's record of outstanding performance ever since 1900 backs these products. *Lone Star Cement Corporation . . . Santa Fe Building, Dallas . . . Esperson Building, Houston.*

*Reg. U.S. Pat. Off. †Trade Mark

...Keeping pace with Oil-Industry Progress

LONE STAR CEMENT CORPORATION

Makers of . . . Lone Star . . . 'Incor' . . . 'Starcor' . . . 'Texcor'

Diesel-Electric Rigs in Gulf Coast Service

PETROLEUM ENGINEER Exclusive Feature

☆ Adverse conditions in Mississippi Delta area have proved rugged flexibility of electric power for drilling

by Orville Adams

ORVILLE ADAMS

was educated at Kentucky State College and served in the technical branch of the army during the World War—After his discharge from the service he was for ten years sales engineer for Diesel engine manufacturers—Since 1930 he has devoted his time largely to the writing of text books and articles for leading technical journals—Is the author of authoritative text books on the Diesel engine that are widely used in technical schools, and at present is preparing a text on Diesel engine thermodynamics for college use—Is also engaged in research and investigation and the preparation of engineering reports on Diesel engine applications.

THE flexibility of the Diesel-electric drilling rig, particularly the variable voltage transmission type, makes its application practicable and feasible under many conditions encountered in the field. Typical of these applications are the rigs operated by the Rowan Drilling Company. The rigs described here are mounted on barges for operation in the marshy coastal regions in the Mississippi Delta sections of Louisiana. The two rigs to be described are known as Rig Nos. 1 and 6, so designated for description of the equipment. The original equipment on each rig comprised a total of 400-kw. generating capacity and two Diesel engines. The generating unit for Rig No. 1 comprised two 200-kw. generators on a common shaft to which two Diesel engines were connected through V-belts. The original generating unit on Rig No. 6 was a 400-kw. generator connected by V-belts to two Diesel engines. To each of these rigs were later added two Diesel-generating sets, the engines being direct-connected to the generators, making four engines on each rig, giving each drilling rig 800-kw. generating capacity.

Rig No. 1. The original engines on this rig were two 6-cylinder Diesels having a 9-in. bore and 12-in. stroke and developing 250 hp. at 600 r.p.m. Two 8-cylinder 300-hp. Diesels were added later. The original engines drive 1200-r.p.m., 200-kw., 200-v. d-c. generators; the other two engines are direct-connected to 200-kw., 400-v. d-c. generators. The equipment is operated as follows:

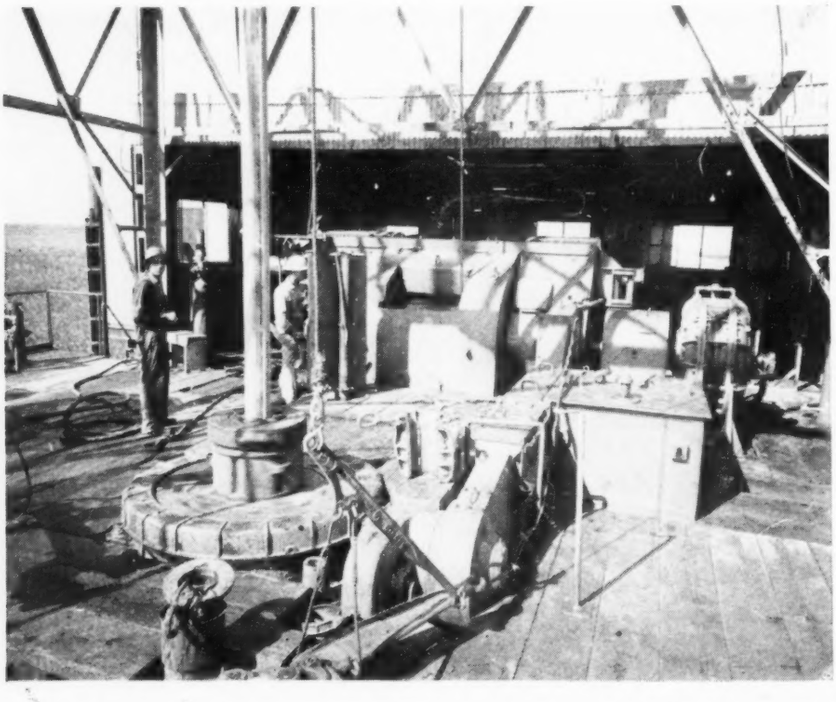
While drilling, one 200-kw., 200-v. generator is used for the rotary when just rotating. The other 200-kw., 200-v. generator supplies power to the motor on the 7½ by 18 mud pump. Two 200-kw., 400-v. generators are operated in parallel, supplying the 400-hp. motor driving the mud pump. When coming out of the hole the two 200-kw., 200-v. generators, operated in series, are paralleled with one of the 200-kw., 400-v. generators.

Rig No. 6. Two 8-cylinder, 300-hp. Diesels are used in connection with two 300-hp. Diesels of a slightly different type. The latter two engines drive one 400-kw., 400-v. generator, each of the former two being direct-connected to a 200-kw. generator. This rig is operated as follows:

Normally the two engines driving the 200-kw., 400-v. generator are used on a 400-hp. mud pump. One of the engines driving a 200-kw., 400-v. generator is used to drive the rotary table. Coming out of the hole the generators are used as follows: One 400-kw., 400-v. generator is operated in parallel with a 200-kw., 400-v. generator. These three engines and two generators supply power to a 400-v., 400-hp. motor driving the drawworks. The other engine driving a 200-kw., 400-v. generator supplies power to the mud pump.

The practicability of the Diesel-electric rig may be credited to two factors: the development of the present-day, high-speed Diesel engine of adequate size, and the perfection of the variable voltage transmission.

The type of Diesel-electric rig described here, with its variable voltage



Barge-mounted electric rig drilling in the Mississippi Delta country

. . . YOUR AID TO BETTER CEMENTING

Larkin
Spiral Type
Centralizer

Larkin
Straight Type
Centralizer

Keeping your casing string "in the groove" is not only a basic requirement of a successful cementing operation, but one of the most important points of your cementing job. A uniform annular space around the pipe, near the shoe, is a uniform cement ring in the making . . . and this uniform ring of cement between the casing and formation means a minimum of channeling.

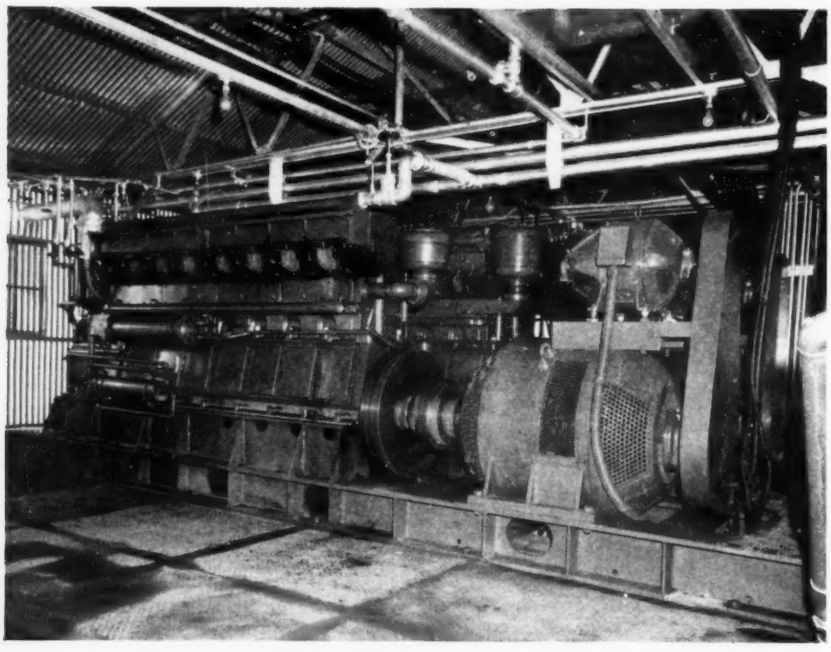
Casing running problems vary just as depth, formation, and other conditions vary in different areas . . . and Larkin has met this varied problem with two distinct types of Casing Centralizers, pictured here. They are alike in that both are extremely simple in design, easily applied, and both ruggedly constructed of fine materials for dependable operation. The spiral type is 42 inches long; the straight type 18 inches. Each matches its own particular problem with which you are familiar.

You'll find full description, specifications, and prices on page 1427 of your 1941 Composite Catalog, and in the Larkin Catalog. Both types are available through your Supply Store or any Larkin Warehouse.

LARKIN

LARKIN PACKER COMPANY, INC., St. Louis, Mo.

WAREHOUSES: Houston, Corpus Christi, Odessa, Shreveport, Tulsa, Great Bend, Salem.
EXPORT: 74 Trinity Place, New York City



One of the 200-hp., 400-v., variable voltage generators driven by a 375-hp. Diesel engine on Rig No. 1. Top-mounted exciter is rated 25 kw., 125 v.

transmission, embodies the many advancements that have been made. Fundamentally the arrangement comprises d-c. generators, a portion of whose fields are supplied by separate excitation, and whose voltages are varied or reversed by controlling their fields. It also includes motors with shunt fields separately excited, so that their direction of rotation and speed can be changed when the polarity and value of the generator terminal voltages are changed, together with constant voltage exciters to provide for separate excitation, and generators and motors for auxiliary power. In connection with these generators and motors, it also includes control equipment capable of full control of power application to all main motors for drilling and hoisting from the driller's position. The application of these factors to the arrangement of equipment on the Rowan rigs has numerous advantages.

The generators are not only variable voltage generators, but they have a characteristic voltage curve that droops to zero at some predetermined current value. This has for its purpose the following:

(1) The peak-generator output, and consequently the peak demand on the engines, is limited to the maximum output of the Diesel engine.

(2) Once this limit is established the protection of the engine against overload is automatic, regardless of the table, pump, or hook load.

(3) The maximum current when the motor is stalled is limited to that value which is safe for the mechanical and electrical equipment, a limitation that is essential for mud pump and table drives.

A Diesel-electric drilling rig of this type is usually known as the "full-electric" rig. With this type of drilling rig, the drawworks, table, and mud pumps are all driven electrically. The table may be driven, however, by the drawworks motor through the drawworks, or by a separate table motor, as in this case. The pumps may also be driven mechanically, in which case the rig would be known as the "semi-electric."

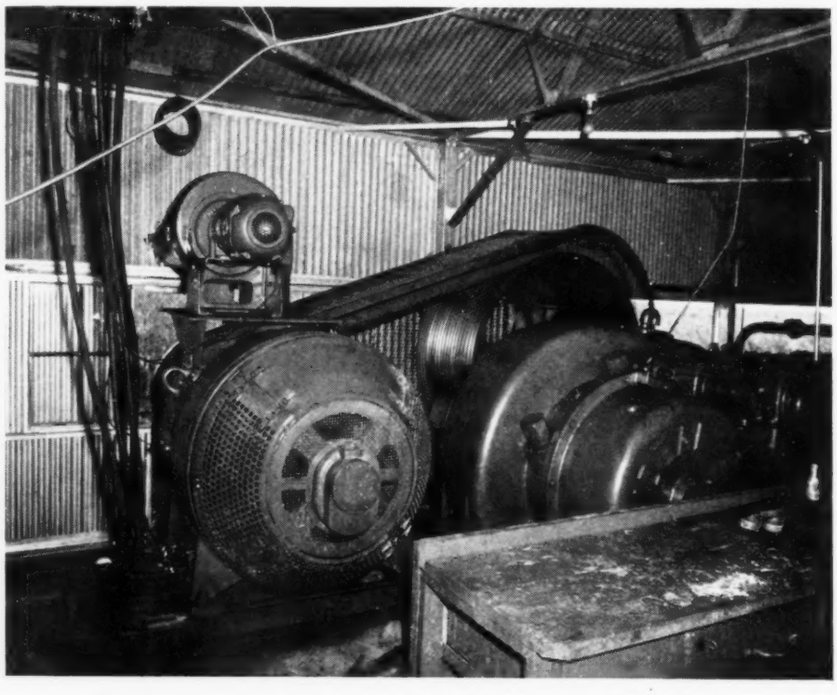
The characteristics of a variable-voltage d-c. transmission equipment for oil-well drilling are as follows:

(1) The manipulation of the engine clutch to pick up the load is eliminated. The clutch is used only when starting the generator sets. This reduces the expense of clutch maintenance and time due to delay in starting. It also eliminates the shock loads on the engine and the mechanical equipment that usually accompany clutch operation when picking-up loads.

(2) It is practically impossible to overload or stall the Diesel engine; thus the engine operates at practically constant speed regardless of the load, a condition most desirable if the engine is to give maximum efficiency and the design kept down to the minimum of complications in control equipment.

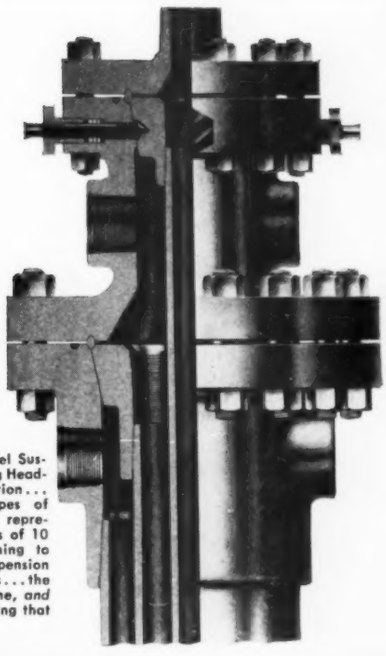
The load can be picked-up smoothly and quickly, therefore, for the inherent characteristics of the electrical control avoid shock loads on the engine and mechanical equipment.

It follows that a wide range of motor speeds and torques are available. The voltage at light loads and the operating speeds when lifting such loads may be as much as 15 to 25 percent



A 400-hp., 400-v., 900-r.p.m. semi-enclosed forced ventilated motor driving a 350-hp. mud pump on Rig. No. 1

Whip Pressure Equalization



This is Type 9M Mandrel Suspension RECTOR Casing Head-Tubing Head combination... one of numerous types of RECTORHEADS which represent the unique results of 10 years of head designing to solve specific pipe suspension and sealing problems... the result of sticking to one, and only one, job; and doing that job well.

AND YOU'VE WHIPPED TODAY'S NO. 1 PRODUCTION PROBLEM!

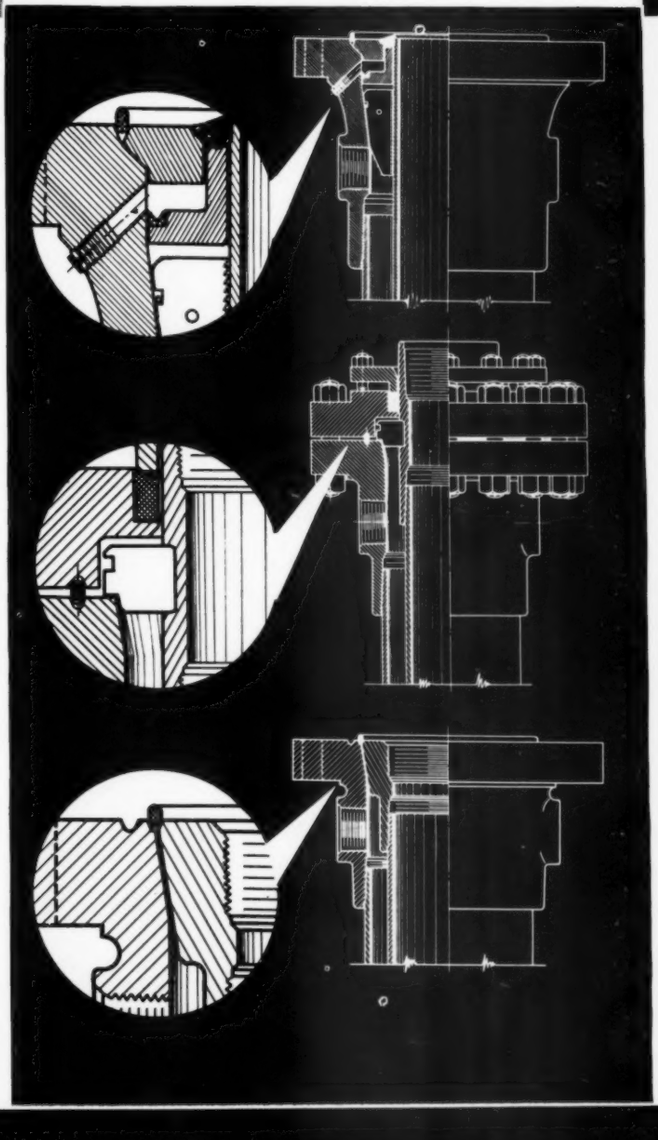
The oil fields today are menaced by many wells in which "between-string" pressures are equalized. You know the seriousness of this. Blow a nipple off your Christmas-tree and you still have a valve to shut off pressure. But let something go haywire with your casing head and you're in a real jam. Several casing head weaknesses can cause equalization of pressure, but CRACKED WELDS and LEAKY PACKING are the outstanding ones . . . and they're enough!

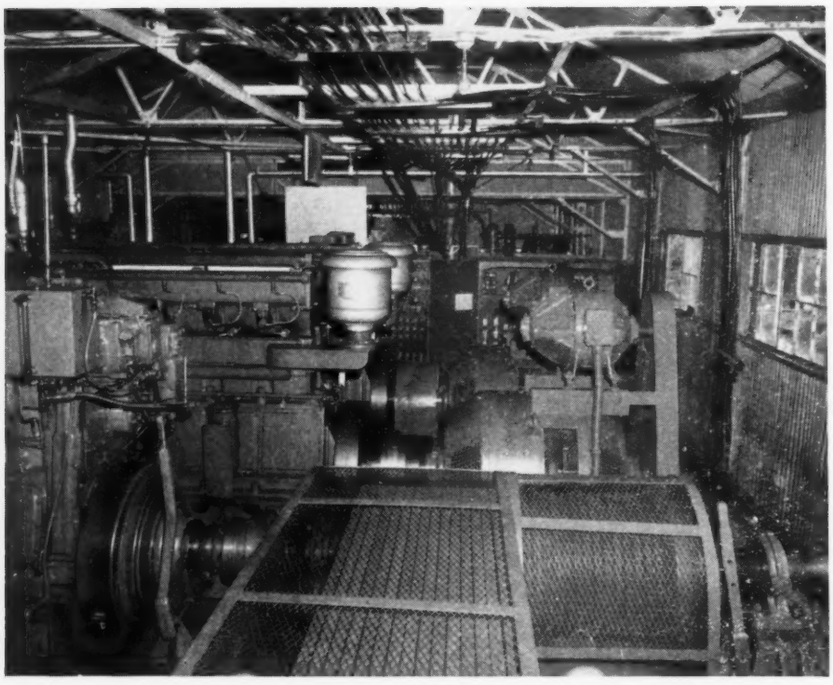
Through years of experience we know, and have proved, that pressure equalization *can be prevented*. More than 15,000 RECTORHEAD equipped wells, without a single case of equalized pressure, is proof enough.

It's just a simple matter of practical design and construction . . . of sticking to one job, and doing that job well. RECTORHEADS have vital patented features which cannot be duplicated nor, except for a lot of trouble-making trigger-work, cannot even be approached. RECTORHEADS follow API construction right down the line . . . incorporate the API iron ring . . . do not depend on fabric or plastic packing, in no case employing it unless it is fully replaceable under pressure. RECTORHEADS have only two flanges. Any more than that are just excess weight and extra cost. Three types of RECTORHEADS, illustrated at right, provide every possible means of safely suspending pipe... the Slip Suspension Type, the Split Ring—Recessed Coupling Type, the Mandrel Suspension Type. Yes, there's no excuse today for using any casing head that has not stood the test of time, that will not get the job done in an emergency... there's no excuse for inviting danger to the very foundation of your well... there's positively no excuse for equalization of pressure... not as long as there are RECTORHEADS!

RECTOR WELL EQUIPMENT CO. INC.
"MAKING THE OIL INDUSTRY SAFER"

Buy RECTORHEADS
Through Leading Supply Stores





In foreground, 2 engines compounded drive one 400-kw., 400-v., 1200-r.p.m. generator through V-belts—the two direct-connected engines in background each drive a 200-kw., 400-v., 600-r.p.m. generator. Rig No. 6

above the rated speeds. It is also possible to handle full-load torques satisfactorily at several speeds, ranging all the way from zero to full speed. Actually, it has been found that torques from 40 percent to 200 percent of full load torque can be exerted at zero speed, as the maximum torque at zero speed can be predetermined.

One of the advantages that has been pointed out is that operating records can be easily obtained, the engine performance readily checked by measuring the engine-generator output, as well as ascertaining the power consumption for the various operations. Moreover the engine operating conditions may be obtained at any time.

The location of the equipment around the operation to the best advantage, the placing of the mud pump, power plant, and auxiliary equipment at the most convenient places are other examples of the flexibility of this type of rig. One or two large engines, or several small engines, can be used, and two separate assemblies may be used on a single rig to double the power available when needed for deep drilling, or one assembly may be removed when not needed. When generators are connected in series, having one engine down does not reduce the maximum hook power available. In addition to the generator and engine equipment, a full electric rig of this type usually comprises the following motors:

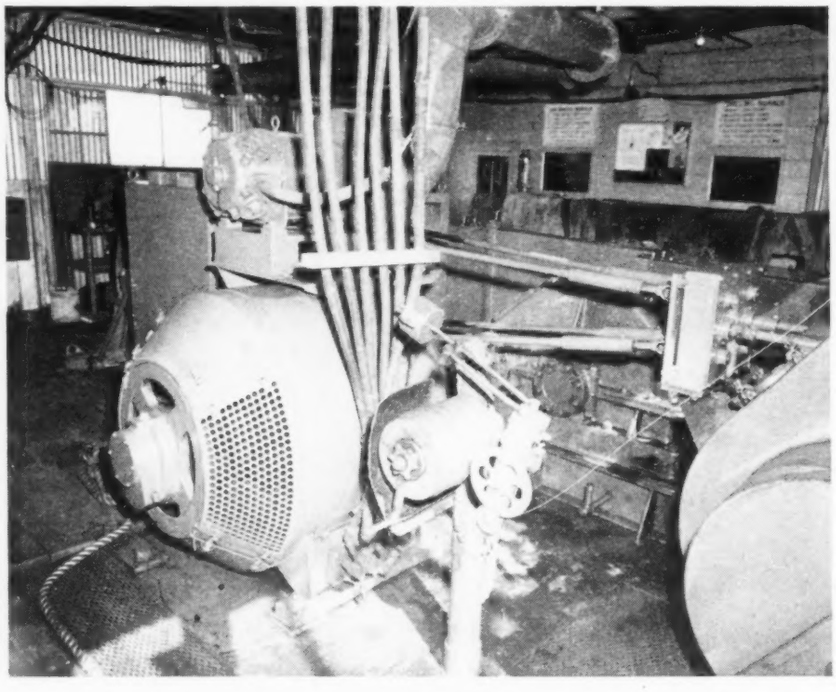
1. Drawworks motor; usually a 200/400-hp., 200/400-v., at 450/900 r.p.m.

2. Mud pump motor, usually 300/400-hp., 200/400-v., and one 200-hp., 200-v. auxiliary mud pump motor.

The electrical control equipment would comprise one complete variable voltage control assembly including the various control apparatus, viz: (a) one main control cabinet, containing contactors, relay switches, exciter meters and rheostats; (b) one derrick floor resistor rack, containing field resistors with oil-immersed, reversing master controllers mounted thereon; (c) one drawworks post-control mechanism, with wheels arranged so that the generators may be controlled independently during drilling or simultaneously during hoisting, and (d) an oil-immersed selector switch to set-up circuits for drilling or hoisting and one explosion-proof emergency push button, and a meter cabinet with an ammeter for each generator circuit.

The Diesel engines used on these rigs are of the stationary type, and are available in 6- and 8-cylinder units. The base and centerframe of these engines are cast of Meehanite metal in one piece and are very rigid. Power cylinder liners are of the wet type, and are convertible to gas operation by changing cylinders. The engines are fully equipped with the essential auxiliary equipment, comprising air filters, silencers, oil and fuel filters, gauge indicators, and thermometers.

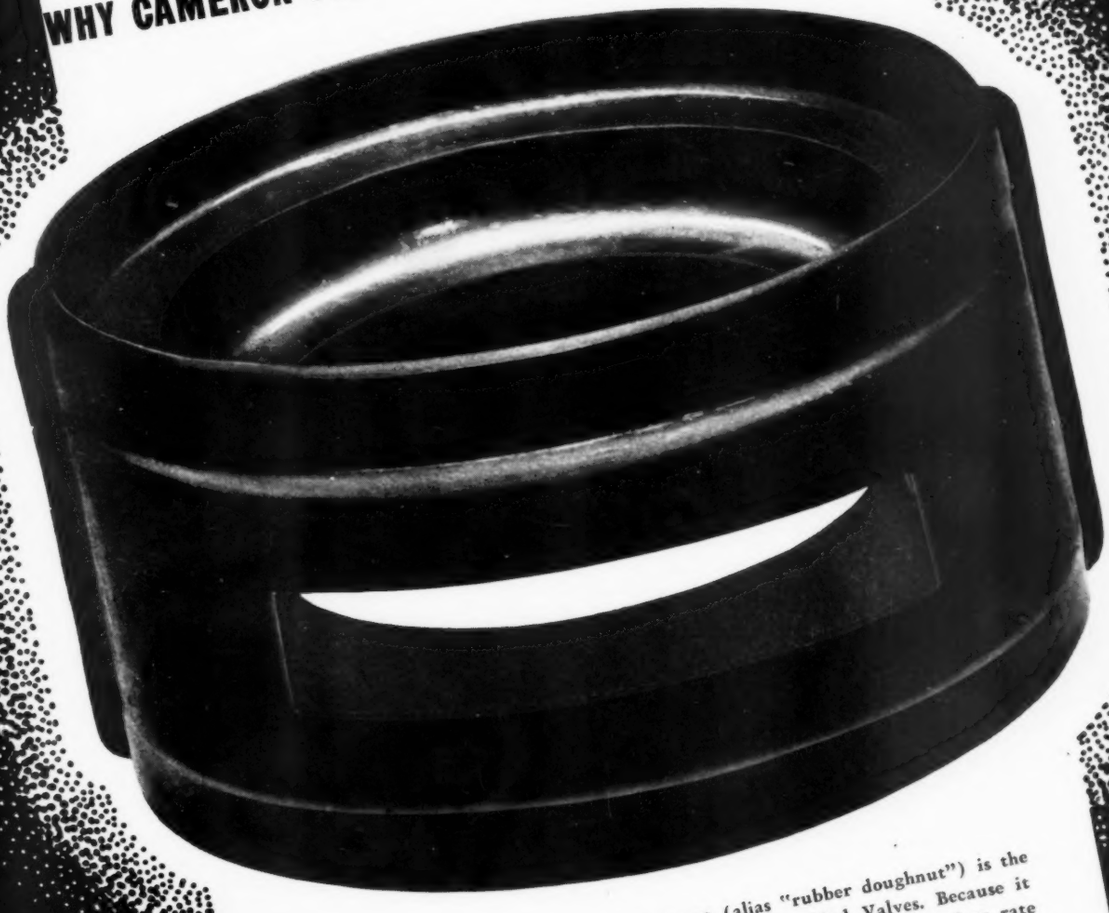
The operation of these rigs in the Mississippi Delta on barges under conditions that provide a wide range of flexibility and adaptability and performance tests indicate adequacy of this type of equipment. On such locations, completely self-contained rigs, having high flexibility and reliability are a necessity.



The drawworks motor on Rig. No. 1 is a 400-hp., 400-v., 900-r.p.m. semi-enclosed unit with top-mounted blower. Resistor racks are hidden by motor

Rubber Dough

WHY CAMERON FLEX-SEAL MUD-VALVES SAVE 93%

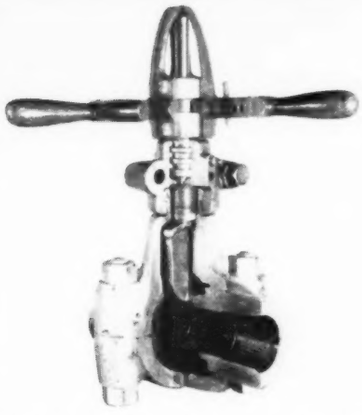


This renewable resilient flow-way insert (alias "rubber doughnut") is the key to the remarkable success of Cameron Flex-Seal Mud Valves. Because it absorbs the cutting action of abrasive-laden fluids at an extremely slow rate of wear, and may be easily replaced in the field at small cost, this unique insert is largely responsible for the elimination of 93% of the maintenance required by conventional mud valves and stop cocks. Tested with competitive type valves under identical operating conditions in a deep Gulf Coast field, Cameron Flex-Seal Mud Valves required an average of only $1.34 per well for repairs, whereas the competitive type valves required an average of $22.50 per well.

The cross-section photograph at left clearly shows how the resilient insert seals the two-piece valve body and provides a pressure-tight seat for the gate. Note, also, the simplified mechanical design of the valve—its bolted body and bonnet which permits easy replacement of parts in the field with ordinary rig tools . . . the hubs (with any type end connection desired) which swivel like a union when the body bolts are loosened . . . the lip-type stem packer which requires no packing gland, and the many other exclusive features.

Now available in 4000- and 6000-pound test models

Get the Most for Your Mud Valve Dollar . . . CAMERON-IZE!



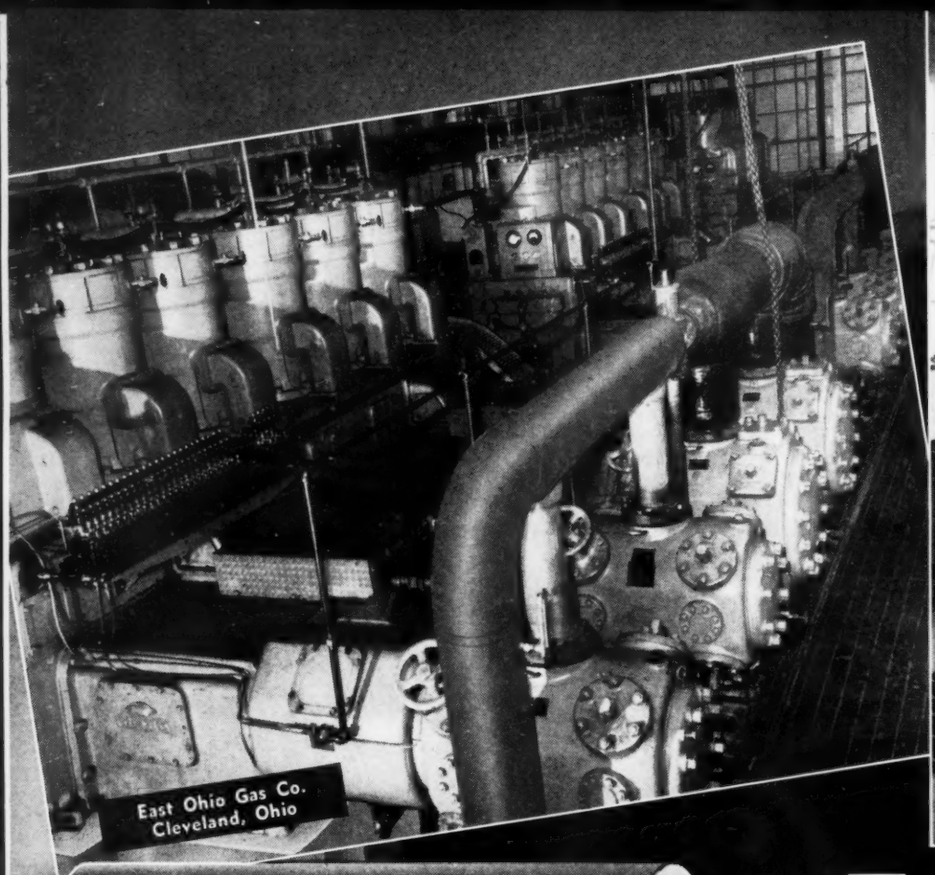
Cross-section view of a 6000-lb. test model Cameron Flex-Seal Mud Valve with renewable resilient flow-way insert shown in red.

CAMERON IRON WORKS, INC.

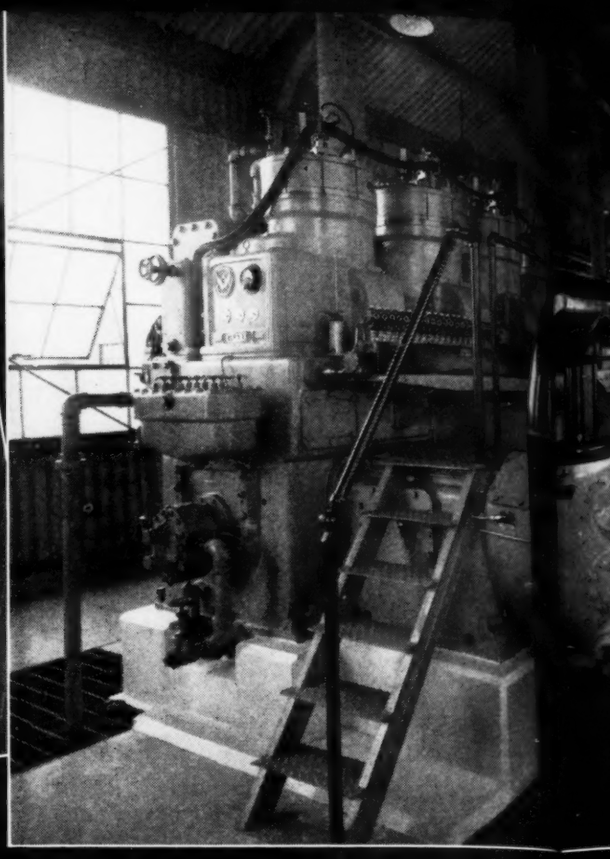
711 MILBY STREET HOUSTON, TEXAS

Export: 74 Trinity Place, New York, N. Y.

California Distributor: The Howard Supply Co., Los Angeles Oklahoma Representative: Paul Edkin, Tulsa



East Ohio Gas Co.
Cleveland, Ohio



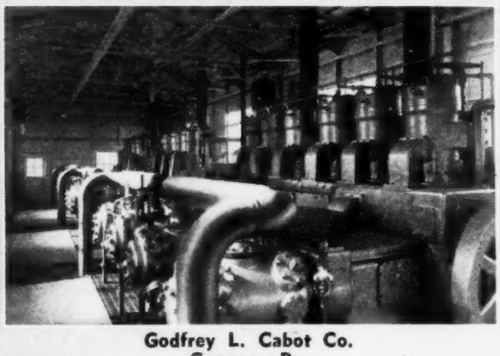
49,700
CLARK A

COMPRESSING N

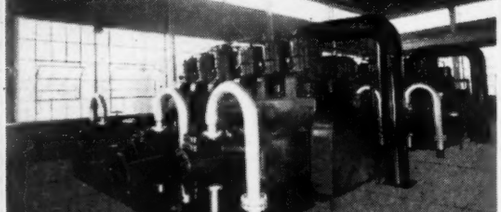
In a little less than 5 years on the market, CLARK "Angles" totaling 49,700 B. H. P. have been installed by natural gas companies as gas driven natural gas compressors. A grand total of 340,000 B.H.P. of these compressors are now in operation, a new world record for compressor sales.

Natural gas companies are using CLARK "Angles" primarily for gas boosting service in main pipe line stations and municipal plants — but they are also using them for many other purposes, such as their use for refrigeration in the new gas liquefaction plant of the East Ohio Gas Company.

The leadership of CLARK "Angles" has resulted from the important economies they have introduced: (1) Lower transportation and erection costs; (2) Smaller foundations and floor space; (3) One-third fuel saving, due to CLARK patented fuel injection; (4) Lower maintenance due to mechanical simplicity. You should investigate these savings. Our engineers will be glad to go into full detail.



Godfrey L. Cabot Co.
Genesee, Pa.



Panhandle Eastern P. L. Co.
Tuscola, Ill.

Gas Booster Installation
in Pittsburgh, Pa. District

CLARK BROS. CO., INC.—OLEAN, N.Y., U.S.A.
Export Offices: 30 Rockefeller Plaza, New York.
Domestic Sales Offices and Warehouses: Tulsa, Okla.; Houston, Texas; Chicago, Ill.; Boston, Mass. (131 Clarendon St.) West Coast Offices: Smith-Booth-Usher Co., Los Angeles, Cal. Foreign Offices: 72 Turnmill St., E. C. 1, London; 4 Str. General Poetas, Bucharest, Roumania.

CL

Canadian River Gas Co.
Dalhart, Texas

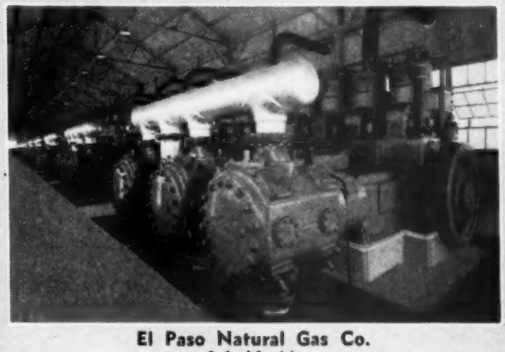
Memphis Natural Gas Co.
Wilmot, Ark.

B.H.P. OF "ANGLES"

NATURAL GAS

Among the natural gas companies using CLARK "Angles" are:

Belmont Quadrangle Drilling Corp.
Canadian River Gas Company
Carnegie Natural Gas Company
Colorado Interstate Gas Company
Columbian Carbon Company
Columbian Fuel Corporation
Consolidated Gas Utilities Corp.
Dominion Natural Gas Company
Eason Oil Company
East Ohio Gas Company
El Paso Natural Gas Company
Empire Gas & Fuel Company
Godfrey L. Cabot Company
Hanley & Bird
Interstate Natural Gas Company
Kentucky-W. Virginia Gas Co.
Manufacturers Gas Company
Manufacturers Light & Heat Co.
Memphis Natural Gas Company
Mississippi River Fuel Corp.
New Mexico Gas Company
Panhandle Eastern Pipe Line Co.
Penn York Gas Company
Union Gas Co. of Canada
United Fuel Gas Company
West Texas Gas Company



El Paso Natural Gas Co.
Jal, N. M.

Eason Oil Company
Crescent, Okla.

Memphis Natural Gas Co.
Monroe, La.

ARK

Affiliated Companies
Dresser Manufacturing Company, Bradford, Pa.
Bryant Heater Company, Cleveland, Ohio
Pacific Pump Works, Huntington Park, Calif.
Van der Horst Corporation of America.
Porous Chrome Hardening for engine parts.

Small, Growing Companies to Pay Most Excess Profits Tax*

THE purpose of this article is not to explain the inner workings of the new excess profits tax law. It is being written for the oil man himself; not for his tax attorney or accountant, as they have access to tax services and periodicals. This will be an attempt to show as plainly as possible that the heaviest burden of the new tax will fall upon those companies that started in a small way and still are considered "little fellows" when compared with the giants of the industry.

Everyone in business knows what "return on investment" means; therefore, it is clear to every oil man who has signed a corporation tax return this year that if his company doesn't make more than 8 percent on the investment in his company, it won't have to pay any excess profits tax under the present law. This investment for tax purposes is represented in general by the following:

The amount originally put in the company
Plus additional sums put in later
Plus profits left in
Plus one-half of money borrowed on notes given by the company.

It is well to remember that, under the law as it now stands, mere increases in value as the result of development are not considered as an investment, because such increases whether in market value or barrels of oil, were not put into the company. Instead the company itself bought leases that proved to be worth more than they cost, after all the cost of developing and equipping them had been paid out.

If your company is making better than an 8 percent return on your investment in it, and it looks like this tax is going to be assessed, there is one other possibility that may keep the company from paying it, and that is if your company is not now making any more net profit than it did on the average during the years 1936 to 1939, inclusive. Either plan may be used, that is, the return on investment plan or yearly average of income for four years before the defense emergency arose.

Now, if you find that a tax will have to be paid under either plan, it is obvious and natural that you will choose the cheaper of the two, and you will also ask your tax man to see if your company is entitled to any of the special credits. . . . It is suggested that you do not try to figure them out yourself, unless you happen to be a tax man, because some of them are a little less than simple. It is better to ask questions about these, or ask a tax man to figure them for you.

After getting past the above, and without entering into a discussion of any of the possible complications that might affect a particular company, you naturally will want to know how much the tax bill will be. Now we come to the purpose of this article, namely, to point out that the new law does not specifically take care of one certain situation in the oil industry that is going to produce the laying of a very heavy excess profits tax on the company that finds itself in that situation.

It is believed desirable to keep this article away from actual figures so far as possible, because their injection at frequent intervals usually tends to obstruct the flow of thought. Anyway, we can try it without figures and see how we get along. Let's draw a picture step by step. . . . You may know a number of companies in this condition. Assume a comparatively small oil producing company that was started on a so-called "shoestring," namely, two or three leases that didn't cost very much —in the latter part of 1935. This means, of course, a small original investment. Development started early in 1936 and progressed on all the leases, which proved productive as tested, in a fairly steady manner, one well after another, until the latter part of 1939, when the leases became fully developed. All this development was done on money borrowed as and where it could be found at comparatively high rates, together with credit extended by supply houses. As this development went on, the company was advised to charge all drilling and development costs (not casing, tubing, tanks, or other physical equipment) to expense account in accordance with the privilege granted by the government. The obvious result of these charge-offs is that, in addition to having a small investment, the company very likely made little or no net profit during the years 1936 to 1939; but now finds itself with fully developed leases, all making their allowables, and with no expense to deduct from its oil run revenue except lifting costs, depletion, depreciation, taxes, and ordinary overhead expenses, leaving a substantial net profit beginning with 1940 only because there are no more deductions for drilling and development, and not as a result of any appreciable increase, if any, in oil run revenue over previous years. In addition it so happens that, whereas this company has bought several wildcat and semi-proven leases, none of these has had the benefit of producing offsets and they are not considered quite good enough to warrant drilling any test wells on them, so the company most likely will have no further drilling for a long time. We might even consider that this company has no leases at all other than those already fully developed, but it is deemed best to draw a sort of double possibility picture at this point, so both conditions will be covered.

No doubt the picture, by this time, has revealed itself sufficiently to make the reader wholly aware of what is about to happen in the way of taxes to this small company about which we are writing. Yes, this company will have to pay an excess profits tax on practically all its net profit (after deducting the normal income tax of 24 percent or more), even though it produces little, if any, more oil in 1940 and succeeding years over and above what its average annual production was from 1936 to 1939. There will be, in truth, no excess profits, but it will have to pay an excess profits tax nevertheless.

Congress included a provision in the law that is supposed to relieve this situation, but the effect of this provision in most instances will be negligible or will give no relief whatever.

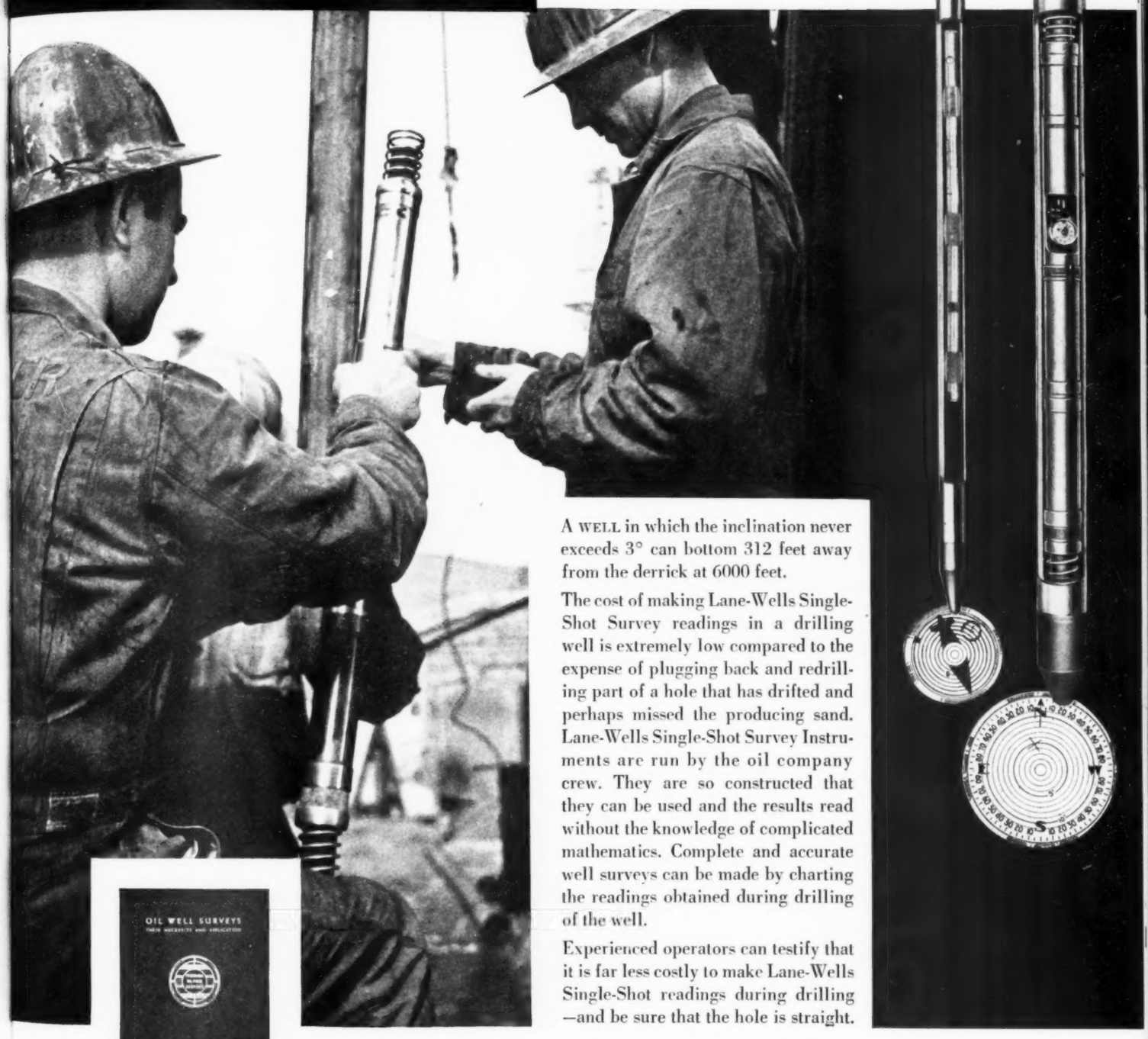
As a result of this condition, many small independent companies without doubt are going to find that about the time they believed they would be in a position to repay the loans made to develop their original properties and to stay in business by purchasing and developing new properties, the excess profits tax, together with the high income tax, will take approximately one-half of their net profits, leaving them possibly an entirely insufficient amount to take care of loan and normal replacement requirements. On the other hand, from the standpoint of the stability of the industry as a whole, a great number of such companies, in an earnest effort to acquire replacements and develop them during these high tax years, may overlook the natural hazards of the business and engage in a vast amount of unnecessary drilling; believing it will be done at government expenses, whereas, in truth, the industry, in general, and those who do this, in particular, will really be the sufferers.

This is a serious matter for the small independent companies, and the entire oil industry as well, and Congress should be made aware of it.

*Prepared by tax authority for the Independent Petroleum Association of America.

HOW MUCH DOES IT COST—TO DRILL A STRAIGHT WELL

LANE-WELLS SURVEY INSTRUMENTS CUT DRILLING COSTS BY DETERMINING INCLINATION, DIRECTION OR BOTH IN DRILLING WELLS



A WELL in which the inclination never exceeds 3° can bottom 312 feet away from the derrick at 6000 feet.

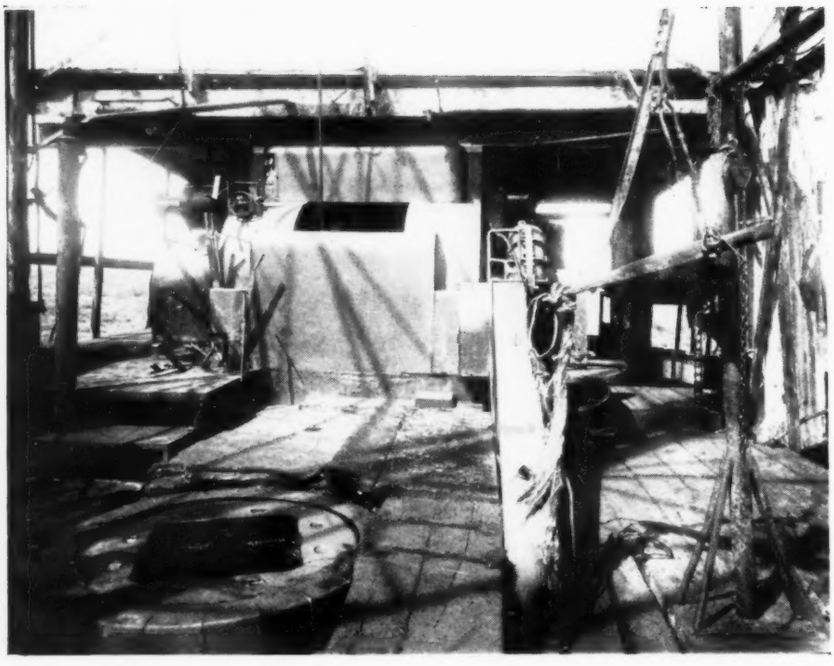
The cost of making Lane-Wells Single-Shot Survey readings in a drilling well is extremely low compared to the expense of plugging back and redrilling part of a hole that has drifted and perhaps missed the producing sand. Lane-Wells Single-Shot Survey Instruments are run by the oil company crew. They are so constructed that they can be used and the results read without the knowledge of complicated mathematics. Complete and accurate well surveys can be made by charting the readings obtained during drilling of the well.

Experienced operators can testify that it is far less costly to make Lane-Wells Single-Shot readings during drilling —and be sure that the hole is straight.

SEND FOR THIS BULLETIN

It gives you complete information about oil well surveys and their applications. Address Lane-Wells, 5610 So. Soto St., Los Angeles, California.

LANE-WELLS TECHNICAL OILFIELD SERVICES *Everywhere*



This rig made 800 round trips in 380 days on one well—a fair sample of the service to which modern equipment is subjected

PETROLEUM ENGINEER Exclusive Feature

By
H. Lee Flood
Associate Editor

Service Record of West Texas Drilling Rig to Date

☆ National emergency emphasizes importance of maintaining drilling equipment to extend useful life

CURRENTLY one of the most critical problems confronting those engaged in the business of drilling oil wells is the impending danger of being unable to procure necessary replacements of existing equipment because of the defense program. At the same time that steps are being taken to insure a more favorable position for drilling equipment in the priority list emanating from the Office of Production Management in Washington, it is advisable that drilling contractors give serious consideration to overhauling and reconditioning present equipment with the objective of keeping it in service for a longer period before being scrapped than is the practice during normal times.

It may even become difficult to obtain necessary replacement parts before the national emergency is ended. This possibility suggests the advisability of giving even greater attention to the proper operation and maintenance of equipment from day to day so that wear and breakage of parts will be minimized.

In the discussion following presentation of a recent paper[1] concerning the care and maintenance of Diesel engines, the speaker was questioned concerning the availability of rings, pistons, and other parts ordinarily replaced when an engine is overhauled. In reply, it was stated that although no shortage exists at present, there is every reason to believe that in six months to a year it may be difficult to obtain parts. This inability to procure parts may mean that engine operators will have to be content with continued service from equipment and parts having greater wear than normally would be tolerated.

Because of this general situation now confronting the drilling industry, it is of interest to consider just how much life and service is being built into present-day drilling equipment. At a time like this when machinery must be pressed for every last hour of service it is capable of delivering, full tribute should be given to the manufacturers of oil country equipment who have so ably and faithfully continued to improve their products during recent years.

Although some remarkable service records have been chalked up by drilling equipment, it is not often that one hears much of them. The business is so fast moving and improvements in design are occurring so rapidly that little interest is shown in equipment during the latter days of its usefulness.

To call attention to the possibilities for profitable use of drilling equipment beyond the normal life usually assigned to such equipment, the service life to date of a drilling rig now operating in West Texas is worthy of consideration. In particular, the lack of repair expense and downtime due to mechanical trouble will be stressed in order to bring out the durability of modern equipment when properly serviced and operated.

Wells Drilled to Date

The drilling rig in question is owned by Bosworth Drilling Company, Odessa, Texas. The drawworks, engines, mud pump, and other equipment on the rig were assembled and placed in operation during June, 1939.

The first well drilled by the rig was situated near Texon, Texas. This well was drilled to a depth of 8269 ft. in 66 days and 12 hours. The average footage of 5 ft. per hour or 120 ft. per 24-hr. day resulted in a record for the field at that time, bettering by 15 days the next best time for any well drilled to comparable depth in the field.

The rig was then used to clean out a well at Big Lake, Texas.

[1] "Care and Maintenance of Diesel Engines" by T. M. Fahnestock. Paper presented at Mid-Continent District Meeting, A.P.I. Division of Production, Amarillo, Texas, March 22, 1941.

LE ROI Drilling Engines

run 24 hrs. a day for 14 months

— without trouble or shutdowns

This remarkable record was established by 2 Le Roi 350 H.P. engines (Series RX1SV) on one well on one location — a deep test by Bosworth Drilling Company, using a Wilson Titan rig as illustrated below. Note these highlights of their experience, as they tell it to you in their own words:

Economy, Long Life
". . . in operation 12,150 hours . . . our maintenance cost has been very low . . . our fuel cost has been very low."

Ample Power All the Way
". . . bottomed at 9187 feet, and at no time were we ever short of horsepower."

Dependable — for Continuous Service
". . . 700 round trips . . . maximum power and maximum flexibility."

Recommended for all-around satisfaction
". . . the engines best suited for drilling service."

Ask other reliable contractors about their experiences, and standardize on the engine they all swear by—Le Roi. Write for complete information on this heavy-duty, V-type, overhead-valve engine . . . also Le Roi 4-, 6-, and 8-cylinder drilling engines. Ask for Bulletin DE4. P-4

BOSWORTH DRILLING COMPANY
BOX 516 ROTARY AND CABLE TOOL DRILLING
ODESSA, TEXAS PHONE 480

February 1, 1941

General Machine & Supply Company
Le Roi Engine Distributors
Odessa Texas

Gentlemen:

We have just completed our deep test for Gulf Oil Corporation located near Royalty, Texas; and thought perhaps you would be interested in knowing of the splendid service our two twelve cylinder 350 H. P. Le Roi engines have given.

These engines are driving a Wilson Titan Model Drilling Rig and have been in operation 12,150 hours. During these many hours of operation, our maintenance cost has been very low. We have been able to operate these engines on natural gas as fuel, and our fuel cost has been very low.

The well we have just completed was bottomed at a total depth of 9,187 feet and at no time were we ever short in horse power. Prior to the drilling of this deep well, we also drilled another deep well at Big Lake, Texas, which was drilled to a depth of approximately 8,400 feet.

Approximately fourteen months time was spent in the drilling of the Gulf deep well and during this time some 700 round trips were made because of fishing, coring, and testing. For this type of work maximum power and maximum flexibility is an important factor in selecting an engine for drilling service.

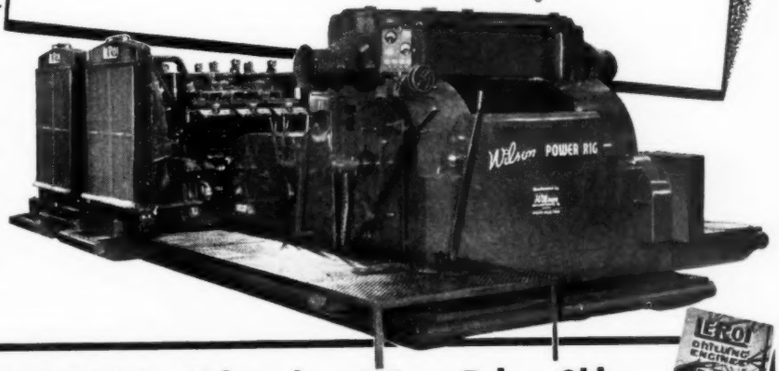
Due to the low initial cost, low maintenance cost, and the splendid service these engines are capable of giving, we do not hesitate in recommending them as the engines best suited for drilling service.

Yours very truly,

BOSWORTH DRILLING COMPANY

PB/hh

By Percy Bosworth



LE ROI COMPANY • Milwaukee, Wis. • Tulsa, Okla.

General Machine & Supply Company	*Wichita Falls — Odessa, Texas*
Southern Engine & Pump Company	*Houston — Dallas — Kilgore, Texas*
Western Machinery Company	*St. Louis, Missouri • Salem, Illinois*

The next well on which the rig was set-up was in Ward County, Texas. The well had been drilled to a depth of 2900 ft. with cable tools but the hole was so crooked that it was decided to change to rotary. The hole had been filled with cement to 2378 ft., the depth at which the rotary rig began drilling.

The equipment was moved-in on November 10, 1939, and the rathole was drilled four days later. From November 14, 1939, to January 19, 1940 (a total of 67 days), the equipment was employed to straighten the hole and drill-by junk left in the hole. Beginning then to drill new hole, the well was drilled to the total depth of 9187 ft. by August 23, 1940. From the latter date to November 20, 1940 (90 days) the contractor was engaged in a fishing operation. Following this the well was plugged-back to approximately 7200 ft. and finally completed on November 29 at a total depth of 7050 ft.

Summarizing this tedious, severe drilling operation, a total of 380 days was spent on the well from the time drilling was begun at 2398 ft. until the well was completed. A total of 800 round trips was made during this period; this indicates the intensive use made of the equipment on this job.

A total of 184 8¾-in. bits and 80 6¾-in. bits was used during this time.

In drilling the chert from 6342 to 6760 ft., 72 and 5 of the 8¾-in. and 6¾-in. bits, respectively, were used. The maximum footage from any one bit was 9 ft. At one point 14 bits were required in drilling only 1 ft. of hole.

Following completion of the above well, the equipment was checked over and the rig moved to a new location on the same West Texas lease. Just recently this well has been completed at a total depth of 7100 ft. Approximately 90 days were required for the drilling.

Thus the rig has had severe, constant use during its operating life to date and it must be kept in mind that this is only a beginning. In more or less continuous service for 24 months, the equipment has been used to drill a total of 22,178 ft. of hole under adverse drilling conditions during a large portion of the time.

The Drawworks

The drawworks used on this rig, purchased new in June, 1939, is designed and recommended for drilling to 12,000-ft. depths with 4½-in. drill pipe.

The chain transmission on the drawworks is capable of transmitting 700 hp. without overload.

The transmission shift is controlled by air pressure. The design is such that it is impossible for the driller to engage or disengage the transmission clutches until the input shaft of the transmission has slowed down sufficiently so that no damage can occur as a result of sudden engagement of the jaw clutches. The action of the air is so controlled that the driller may turn the speed selector, while the rig is running, to the next speed he plans to use. Then when the driller stops the drawworks, the air control automatically shifts to the new speed selected without clash or noise.

The transmission has three forward speeds and one reverse. High and low speed drives to the drum thus provide 6 forward and 2 reverse speeds for hoisting. The rotary drive has 3 forward speeds and 1 reverse.

The rotary table and pump drives are both controlled by internal expanding shoe-type friction clutches. During the time the rig has been in operation these clutches have never been relined and only infrequent adjustments have been required.

The mud pump on the rig is a 7¼ by 18 duplex driven by 18 D section V-belts, each 480 in. long.

The Engines

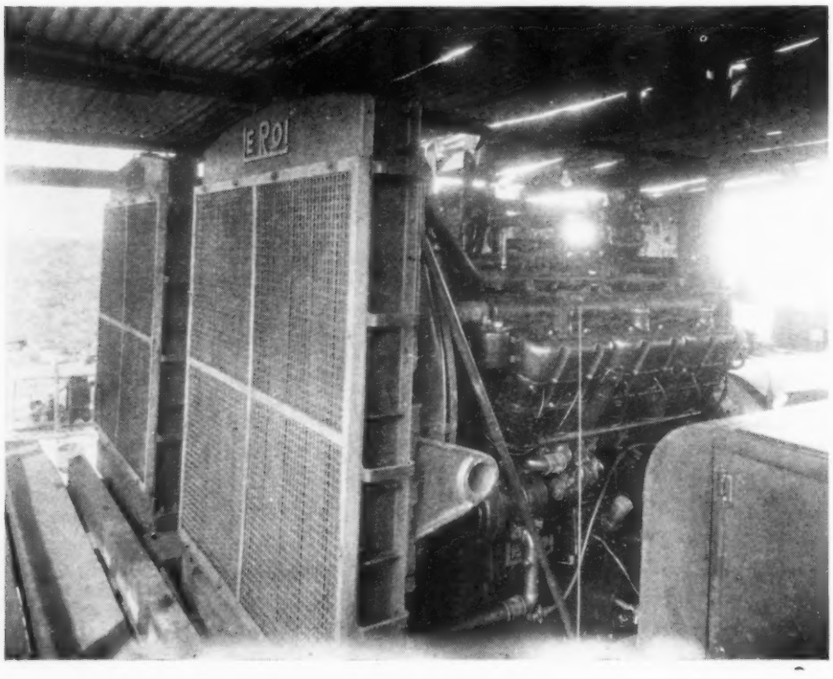
Supplying all power to the drawworks and pump are two 350-hp. engines, each having 12 cylinders of 6¾-in. bore and 7-in. stroke. The rated power is developed at 900 r.p.m. Equipped to operate on natural gas or butane as fuel, the engines thus far have been operated only on natural gas.

On the first well at Texon, the engines were operated for 3600 hours. On the cleanout job, the engines were run for 400 hours. On the long job in Ward County the engines were in service approximately 10,000 hours. Following this 14,000 hours of service, the engines were given a routine overhaul during which all parts were completely checked and either replaced or reconditioned.

When the engines had been completely dismantled, the crankshafts were found to have only 0.001-in. wear and the cylinders 0.006 in. Complete new sets of main connecting rod bearings were installed, and the cylinder heads were overhauled including refacing of the valve seats. All valves were refaced, the radiators were cleaned and repaired, and minor parts were replaced.

During the 14,000 hours of service, repairs and service consisted of (1) refacing the valves on one engine and installing new cylinder head gaskets at a total cost of $120; (2) the four water pumps on the engines were exchanged later at a cost of $112, and (3) spark plugs were replaced and carburetors adjusted as needed at a total cost of $90. Total cost of maintenance during 14,000 hours of service was, therefore, $322, or a cost of only 1.15 cents per engine hour of operation.

The total cost of reconditioning both engines was $1251. If this expense is included as a part of maintenance cost, the total cost was 5.5 cents per engine hour. Following the overhaul, the engines have operated without any expense or downtime, thus indicating that they are capable of serving as efficiently as new engines.



The two 350-hp., 12-cylinder gas-gasoline engines were completely overhauled after 14,000 hours of service

Refinery Practice for the Operating Man

Vocational Class Proceedings in Refinery Engineering

Multiple Coil Cracking

Synopsis of Preceding Meetings

The first discussion involved a review of the various hydrocarbons and their thermodynamic qualities as related to the cracking of petroleum and its products. The main hydrocarbons in petroleum and its cracked products are paraffins, olefins, naphthenes, and aromatics. Of these, olefins are virtually non-existent in most crude oils.

Points covered in the discussion included the following: (1) chemical stability of compounds; (2) relative crackability of hydrocarbons; (3) energies released or absorbed in cracking; (4) the decomposition reactions, and (5) effect of pressure on reactions.

In discussing the development of cracking, it was pointed out that the ability of petroleum to crack was discovered by the accidental overheating of a topping shell still, resulting in an unexpected straw-colored distillate, which was in reality cracked distillate.

Of the earlier cracking processes that followed the first patents on cracking granted to Young and Benton in 1865, the following were discussed: (1) the Benton unit; (2) the Burton-Clark unit; (3) the Coast still; (4) the Fleming still; (5) the Dubbs process; (6) the Isom process; (7) the Cross unit; (8) the Jenkins unit; (9) the Holmes-Manley unit; (10) the Winkler-Koch still, and (11) the Gyro vapor-phase unit.

The importance of clean recycle was first recognized when operators of earlier units discovered that clean stocks permitted longer runs with correspondingly small percentages of gas and coke formed.

In discussing the methods whereby maximum gasoline yield might be obtained by cracking, it was brought out that experience shows that a high reflux ratio results in a smaller yield of gas because of lighter cracking. It was decided to run to coke with as little gas formation as possible. If the residue is fuel oil there is bound to be some gasoline in this liquid product.

The equipment to be used to obtain maximum gasoline yield will be: (1) a pipestill heater; (2) a reaction chamber to give the proper reaction time and to remove the coke, and (3) a fractionating tower to separate the gas and gasoline from the stock. Additional gasoline will be obtained if a multiple coil heater is used so that more rigid control from the fractionator will permit separate cracking from the various cuts at optimum conditions. Quenching will be essential to correct control of the time and temperature element.

The excessive heat brought to the fractionator from the reaction chamber can be disposed of in a number of ways: (1) the charge may be used as a quench; (2) heat can be exchanged with the charge to any adjacent unit, and (3) the remaining heat must be removed by reflux in the usual way.

In summarizing, the factors for higher gasoline yield are: (1) higher reflux ratios; (2) time and temperature control for minimum coke and gas formation; (3) multiple coil heaters to obtain narrow boiling range cuts, and (4) run to coke rather than to any heavy liquid fuel.

If advantage is taken of all present-day developments in cracking it was decided that 75 percent gasoline yield was about the ultimate to be expected.

The time of reaction in cracking doubles when the temperature increases approximately 20 degrees, making it difficult to control the reaction above a certain temperature; in addition, large amounts of gas and coke are obtained.

Refuting the belief that there is a large percentage of free carbon in petroleum coke, reference to several authorities indicated that, on the contrary, coke consists principally of polymerized and condensed hydrocarbons poor in hydrogen and aromatic in nature. Coke is essentially a control product in the operation of a cracking still inasmuch as it is economically necessary that its quality be high if it is to be salable.

Class Meeting No. 5 *(Continued)*

Leader: In recent meetings we have been talking along more or less at random concerning cracking in general. Let's continue the discussion concerning the coke that will be formed. Is it going to be coke that can be removed and commercially usable—how can we control that feature?

Pupil: By the temperature of the combined streams.

Leader: Would that particular arrangement be to the advantage of maximum gasoline production?

Pupil: No, it would not.

2nd Pupil: Even though we have already indicated that maximum gasoline yield is to be our goal, it should be assumed that all must be commercially usable.

Leader: Maybe that will give us the amount of leverage we need to solve this problem.

Pupil: You know it is possible to use coking ovens rather than coking chambers.

2nd Pupil: Another thing—I don't see any provision for taking care of the change in time as you fill the reaction chamber.

Leader: We discussed that in an earlier meeting and decided we had sufficient flexibility.

Pupil: For continually changing them daily?

Leader: Or by individual fires on one or both of the still operations.

Pupil: A limiting factor will be whether we want to go to a zero tar or not.

2nd Pupil: How do they go about making a salable tar? You might get a condensation product in there you couldn't sell at all. Still you couldn't get it out—it would be a mess. Probably you do get it sometimes.

Leader: I expect that would be determined by experience.

Pupil: I wonder whether the proper idea isn't to run the heavy oil coil to produce a coke and the light oil coil to produce gasoline—that's 15 or 20 percent total gasoline expectancy out of the materials that run through the heavy coil.

Leader: All right—that brings up the possibility then as to the various pressures that you would wish to employ on the various stages of operation.

Pupil: Don't you get the gas oil from the dirty material, and recycle through the clean oil line?

2nd Pupil: You by-pass the material and go direct to gas-oil fractions.

1st Pupil: Or possibly take it back into the first fractionating tower. Probably in that type of unit you would end up with much greater than 50 percent flow, through the light oil coils, so that there would be a relatively small flow through the other coils.

2nd Pupil: We discussed briefly Sachanen's idea that we should have a velocity of around 6 ft. per sec. through the heavy oil tubes and 9 or 10 ft. per sec. through the clean oil coil, which would give us a higher transfer rate in the clean oil coil and greater cracking per pass.

1st Pupil: I still can't figure out how many tubes they are going to use. It may be a case of determining how long you should crack it and how long you should leave it there. Sachanen tells you that for every so many degrees, the reaction time doubles.

2nd Pupil: You should have a cer-

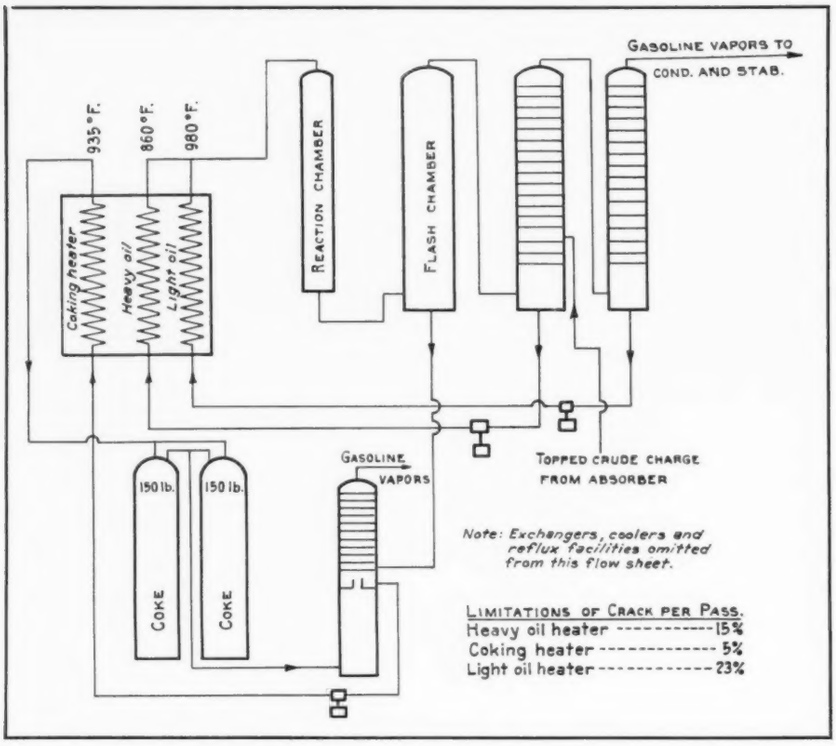


Fig. 11. Representative flow sheet and cracking conditions adopted by class for cracking 26° A.P.I. residuum

tain amount of time for soaking and a certain amount of time for breaking it up. Reaction begins at a certain temperature.

Leader: Let's consider next week the possibility of whether there is a good reason for tying these two streams together. I can't make up my mind whether it is good business or not. In the heavy oil coil, what type of heating curve should you use?

Pupil: Somewhere near level transfer rate.

Leader: You should have a uniformly rising temperature through the coil.

Pupil: You have to consider the transfer rate of the tubes—if you do have uniform transfer, the temperature curve will not be a straight line.

2nd Pupil: Even if you do have uniform transfer rate, you will not have a steady temperature curve. The heat of decomposition becomes effective at approximately 750°F. (399°C.) so that some cracking will take place and as you add a certain amount of heat, part of that heat will be absorbed in the cracking process.

Leader: In other words, to get a uniform temperature rise, you would have to have an increase in heat transfer rate as the temperature rises. There is no reason, however, why the dark-oil coils should not have that uniform temperature rise. As in Fig. 12, the temperature curve would be almost a straight line and the heat transfer curve would have a slight curvature upward. What temperature conditions do you want on the light-oil (clean-oil) coil?

Pupil: As you get in the high temperature, you will probably want the transfer rates lower for mechanical reasons. The trend is shown in Fig. 13.

Leader: In the higher temperature range, the tubes will tend to become weakened—would that be the determining factor?

Pupil: I think it would.

Leader: What would be desirable from a cracking viewpoint?

Pupil: You would want to flatten the curve to get better control of temperature.

2nd Pupil: Are you talking about rates—or total heat?

Leader: We are talking about heat transfer per sq. ft. of heating surface and the curve representing that would tend to increase and then become more nearly horizontal.

Pupil: I think an ordinary flat curve would turn down.

Leader: Then, the temperature curve would go up as in Fig. 13?

Pupil: Yes.

Leader: The idea here, is to heat the oil to the proper temperature and then quench it to control the reaction and stop it at a certain point so that all the reaction will occur in the heater if possible. Is this type of curve the easiest to handle for that particular operation?

Pupil: It is what Sachanen uses in the text.

2nd Pupil: If you will make the temperature increase a straight line function, the reaction is more and more difficult to control.

Leader: It is best to bring it up and then ease off, so I believe this is the kind we want.

Now for next week what would you like to discuss—in what manner would you like to continue this investigation?

Pupil: I don't think we know enough about what is going on.

2nd Pupil: We've got an entirely advanced system of cracking here and we do not have the reactions well enough in mind.

Leader: This isn't an advanced system of cracking.

Pupil: It is, at our stage of study. We should be cracking in a time bomb instead of a two-coil system so that more of us would be able to follow the reactions.

Leader: Would the class prefer to discuss some of the more fundamental aspects now that we have had a chance to see *why* we need these fundamentals?

Pupils: Right.

Pupil: What does the outline call for?

Leader: The outline is based purely on various processing angles. It was understood that when we got to the point where we thought we needed to discuss theory, we would stop and discuss it.

Pupil: Well, here we are.

Leader: Well, let's do it. I believe it is indicated tonight that we need a little fundamental discussion. All right, next week we will discuss the effect of time, temperature, and pressure. Is that all right?

Pupil: That covers everything. I don't know what else you could have. We might stress the effect of pressure to good advantage.

Leader: There will be no problem assigned for next week, then. Prepare to discuss fully the effects of time, temperature, and pressure.

Pupil: One other thing—you mean time, temperature, and pressure in all types of cracking stocks, don't you? It has a different effect on all different types of cracking stocks.

Leader: Yes, on various stocks.

Pupil: That's a lot of work, isn't it?

Leader: We have a lot of ground to cover.

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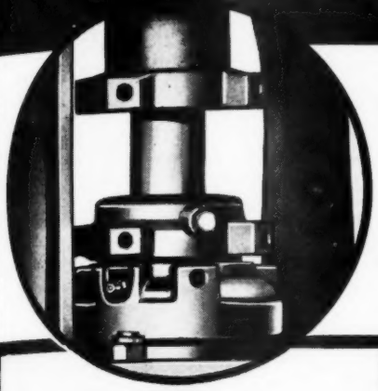

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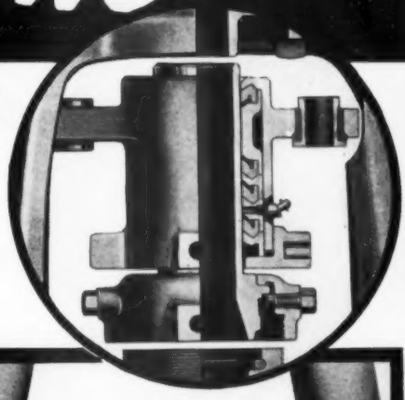

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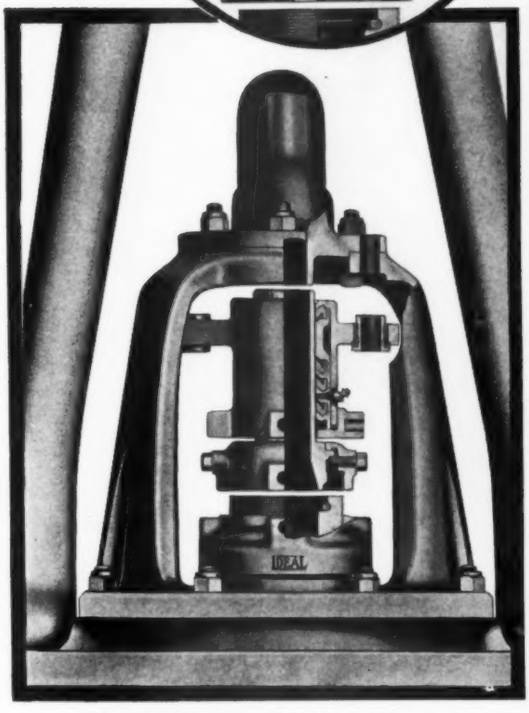

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Class Meeting No. 6

Leader: Last week it was generally agreed that we would devote this evening more to the theoretical side of the thermal cracking operation. One of the questions that came up last week on which we were unable to reach a conclusion was: which of the two cracking methods will yield the greater volume of gasoline, the single coil or the multiple coil? I believe that is as good a place to begin the discussion as any. We will get around to everything before we are through, no doubt. What was the conclusion concerning the number of coils?

Pupil: We were not thinking about that question, but I would say the multiple coil would yield the best gasoline.

Leader: Now let's not hedge. We are after maximum gasoline yield—not best gasoline. I contend that if you know how to obtain maximum gasoline yield from a particular product, that you will also know how to make the best quality, least volume, and every other possible gasoline condition.

Pupil: I don't know which coil arrangement would make the greatest volume.

Leader: How about someone else?

Pupil: In our group, we decided that a multiple-coil operation would be the best for maximum gasoline yield because the yield on the charge will be different from the yield in the recycle oil. Consequently, you will want to operate at a different temperature than you would if you had the two streams together in the same coil. In the single coil if you are operating to obtain the greatest percent yield from the charge, you won't be heating the recycled oil correctly and that applies to each additional pass or cycle as well.

Leader: What are the theoretical conditions for maximum gasoline yield in cracking operation? Will anyone volunteer?

Pupil: Low temperature and long time with no local overheating, and removal of the product as it is formed.

Leader: Let us list the conditions for maximum gasoline yield. What is the first one?

Pupil: Lowest practical temperature. Before enumerating other requirements for maximum gasoline yield, I should like to read a paragraph from a reference book[1] I have here: "By selecting stocks of comparatively narrow boiling range, segregating them according to their refractivity, and cracking them separately under optimum temperature, time, and pressure conditions, it is possible to operate each coil at high crack per pass and so obtain higher yields of higher-octane gasoline, lower recycle ratio, and lower investment and operating conditions."

2nd Pupil: Sachanen on p. 137 of the text says: "The use of too high a recycle ratio as well as too low a crack-per-pass is prohibitive from the commercial standpoint, although the minimum coke formation, maximum yield of gasoline, and maximum operation time are [obtained] with a high recycle ratio."

Leader: Do you believe that the best gasoline yield can be obtained by substituting high temperature and short time for low temperature and long time?

Pupil: I believe that can be done theoretically, but from a practical standpoint it wouldn't be very easy to control the operation when high temperatures prevailed. You couldn't control it practically, but maybe you could work out some theoretical reason why it would work.

2nd Pupil: According to curves showing the effect of time and temperature on rate of cracking, in the cracking range an increase of 5° in temperature will permit a reduction in reaction time that will reduce the length of tubing in the furnace considerably. If you are going to operate at low temperatures in order to avoid excessive skin cracking in the tubes, there will be extremely high velocities through the tubes if the stocks are held in the furnace under low temperature conditions for a long period of time.

3rd Pupil: When the naphthenes are subjected to cracking conditions (and nearly all these oils have naphthenes in them), the predominant reaction will be dealkylation and dehydrogenation in the early stage of the process so that fixed gases are formed very quickly with that type of charging stock.

Leader: Isn't that touching upon our first discussions in which we learned that if we break up a molecule of pure paraffin, it will probably yield a paraffin and an olefin. If we continue to break-up these products, we shall be making butylene and if they are removed from the reaction zone, gaseous material will be yielded instead of liquid. Consequently, it appears essential that they be removed from the cracking zones.

Do we agree that highest gasoline yield can be obtained with low crack per pass?

Pupil: Yes.

EDITOR'S NOTE: Class meeting No. 6 will be continued in an early issue of *The Petroleum Engineer.*

[1] *The Cracking Art of 1937*, by Egloff, Doty, and Jordon. P. 55, Bull. 225, published by Universal Oil Products Company, Chicago, Illinois.

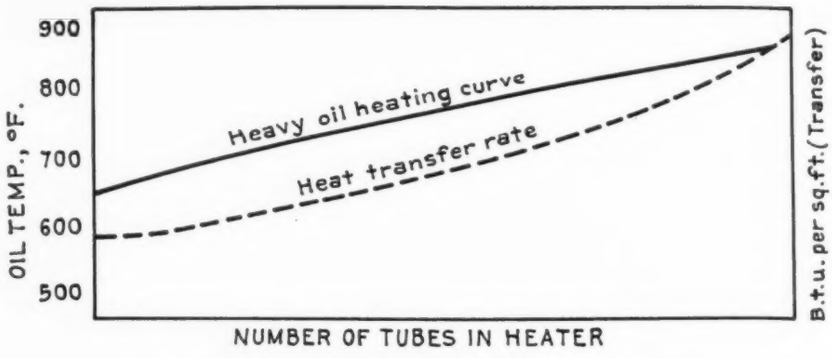
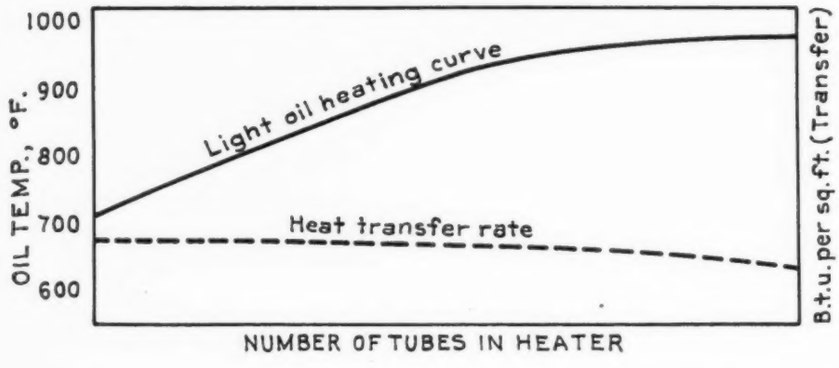


Fig. 12. Diagram of heavy oil heating conditions

Fig. 13. Diagram of light oil heating conditions



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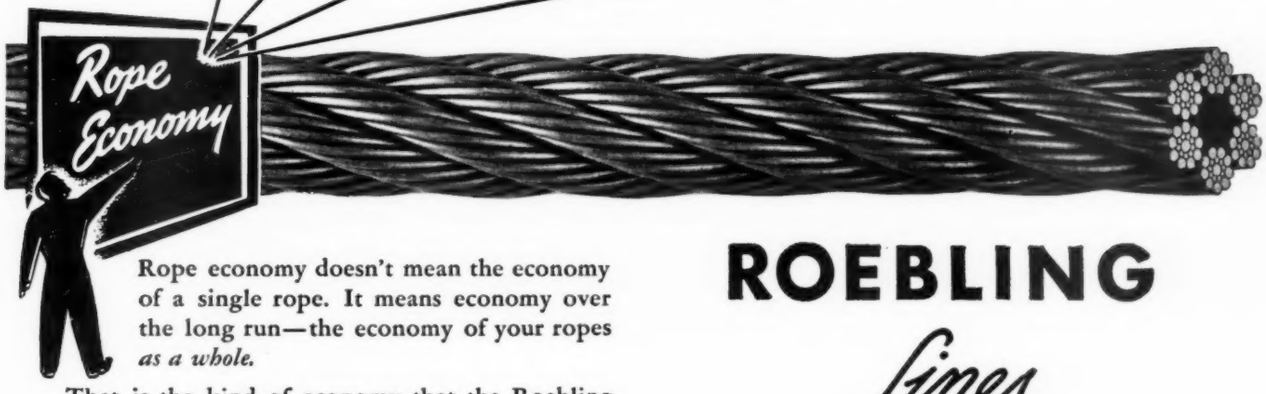

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A Functional Analysis of the Engineer's Place in the Petroleum Industry

PART 4—(Concluded)

by E. N. Kemler, Associate Professor of Mechanical Engineering, Purdue University

THE problem of determining how many engineers are needed in a unit requires careful consideration. Following the outline given it is evident that if every problem were developed in detail there would be an almost unlimited number of assignments to fill. The investigation of every possible item is obviously impractical and undesirable. The determination of which problems would bear investigation is an engineering task and should be the function of the chief engineer or his assistants. As a general economic principle, a subject or problem should not be investigated unless the savings or the benefits will pay the cost of the investigation. There are a few cases where it is desirable to study some fundamental problem because of its general application, future application, or the establishment of a general practice of procedure. It is obvious that to follow the general practice of making an elaborate investigation for every piece of equipment that costs only a few hundred dollars cannot be economical. If the repeated failing of such equipment, however, causes shutdowns or interferes with operations so that a loss in revenue is sustained, the equipment may bear study. An item on which several hundred thousand dollars are spent annually could stand very intensive study, as a reduction in cost of only a few percent would pay for the cost of the study.

The question of what to work on is very important both to the management and to the engineer. It is obvious that if an engineer is going to work on unimportant items he cannot earn a high salary. In the discussion of engineering activities, the things that an engineer should not do were listed. There is a tendency to assign routine, clerical or operating work to the engineer merely because he can do it. Doing such work that better should be done by more moderate priced labor, increases the size of the engineering department unnecessarily. Engineering costs usually are included in overhead expense and as such are subject to very frequent analysis and there is an attempt to keep these costs at a minimum.

A photograph and biographical sketch of the writer can be found on page 27 of the March issue of *The Petroleum Engineer*, in connection with Part 1 of this series.

Relationship with Other Departments

The engineer just as any other specialist must depend on other departments, organizations or agencies for information and assistance. These connections are very important and as has been indicated the complete coöperation between units is necessary for proper functioning and for the full utilization of the abilities of the various specialists. The defining of the duties and responsibilities of the various departments and divisions will do much toward bringing about better coöperation. It gives everyone a better understanding of the way the organization functions and allays the fear that one person may be trying to take over someone else's work. It is only when everyone is working for the good of the company and not a particular department that the best results are achieved. The following discussion outlines briefly some of the important items in which engineers and other departments have joint interest.

Operating Unit

As has been discussed in some detail above, engineers, employed in engineering work should not become involved in operating work. Operating work is a field of endeavor in which engineers may be employed, but as such they are specializing on operating work and not engineering work. For proper coöperation between the operating men and the engineers it is necessary to have a very definite understanding on just what the duties and responsibilities of each are. It is very important that these two units work in unison on the various problems if the abilities of each are to be used to best advantage. The degree to which this will take place will depend on the degree of understanding possessed by the production superintendent as to engineering and its place in the general organization.

Purchasing

As has been stated before, there must be close coöperation between the engineering and purchasing departments on most equipment purchasing. Routine materials and hardware of stock variety may be purchased on specification without difficulty. The specifications, in the case of large volume purchases, may have to be supplemented by physical tests to verify the grade of the commodity being purchased and to see if a different grade could be used. The purchase of equipment of a more involved nature requires that the engineer and purchasing agent work together. In these cases a broad specification is not possible and each design must be analyzed by the engineer before it is given a physical rating and is selected as a desirable piece o equipment for any type of service.

The question as to the best method of obtaining information from sales organizations is of importance. The purchasing departments like to have all inquiries pass through their department. The engineer because of the technical nature of the information he desires, cannot always depend on the average purchasing agent to get it for him. On the other hand if he sees all salesmen he will waste much time talking to people who have nothing to contribute or who cannot answer any of his questions. The engineer obviously should not spend any time with those salesmen who call periodically to see if there are any orders or anything "coming up."

Although the engineer may like to know all the salesmen, it is decidedly to his advantage not to spend a lot of time just seeing everybody. The salesmen who act as such should make their contacts through the purchasing departments. If they have anything of special interest the purchasing department can make an appointment for them with the proper party. Engineers should see sales engineers or technical representatives who have any new data or information or a new piece of equipment to discuss. Although there is

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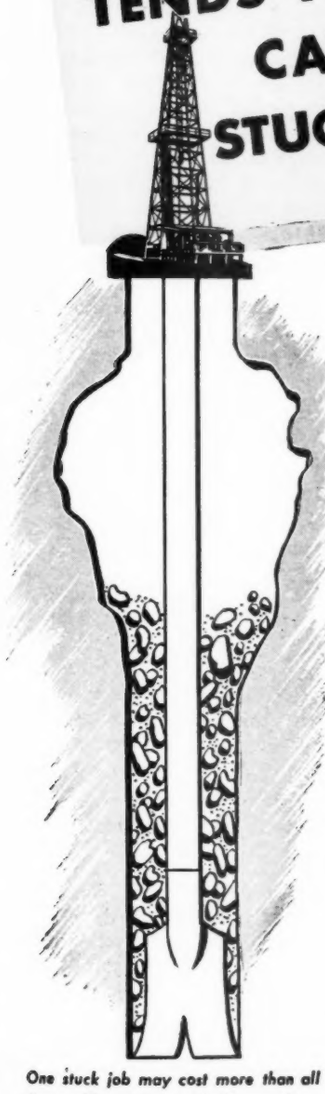

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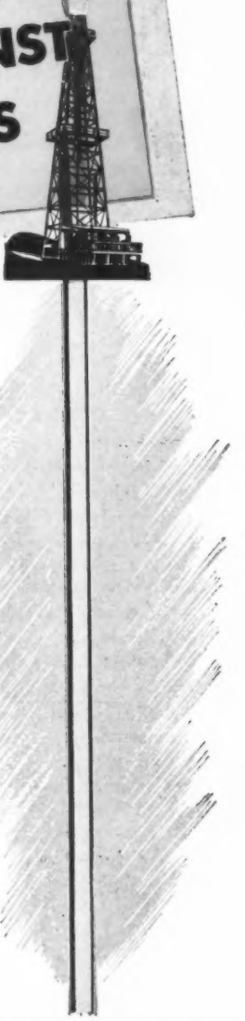

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some danger of passing up something by not seeing everybody there is the danger of passing up some important company business if everyone is interviewed. If someone really has something to sell it will soon be known either from without or within the organization. Manufacturers contribute a large amount of engineering information to oil company engineers and the engineer must keep this source of information readily available through contact. He should not, however, keep the purely sales contacts.

Here again the problem can be very simply solved if there is sincere coöperation between departments. The purchasing department, by seeing the salesmen and passing on only those who have something of interest to the company can save engineers much time and bother. Where large amounts of equipment are purchased important savings can frequently be made if there is close coöperation between the engineering and purchasing departments.

Geological

The petroleum engineering and geological departments both deal with the same general information. They each have a different application of the information. The geologist is primarily interested in finding new oil fields. The petroleum engineer is interested in the development of existing or proved fields. In proved areas the geologist can be used to advantage for special jobs because of his specialized training. Because he has been trained specifically in geological work he is particularly adapted to any problems requiring identification of formations or detailed examination of samples. In areas where location of casing seat is critical the geologists should make the identifications of the proper point. In any case advantage should be taken of his technical knowledge and experience.

The petroleum engineer today covers some of the duties a geologist formerly handled. The previous discussion outlined some of the reasons for this. Because of the overlapping between petroleum engineering and geological work it is obvious that close coöperation is necessary between the two units and the duties, responsibilities, and authorities of each unit should be clearly defined.

Accounting

The accounting department is essentially a record keeping department. Its primary function is to supply useful data and necessary information from its records. The engineer is very much concerned with repair costs and generally with operating repair cost records. The accounting department should keep these records in such a form that they will be of direct value to the engineer in his studies. In this case the engineer should acquaint the accounting department with his requirements and the manner in which he will use the records. The accounting department can then take advantage of existing records and methods in devising forms for such data as are required. As mentioned before, the engineering department should, whenever possible, take advantage of the service departments for the handling of routine reports or information. The analysis and application of the data are, however, very definitely an engineering function.

Personnel

The normal hiring, training and handling of men will come under supervision of a personnel department. Although the routine functions and records of engineers should be handled by this department, the outlining of training programs and the recommendations for handling engineers should come from the engineering department. The actual work of administering the training program outlined should be handled as a routine matter by the personnel department. Likewise the placing and control of the engineers should come under the engineering department's supervision. As outlined, engineering functions are technical in nature and as a general rule a non-technically trained man is not capable of passing on the ability of an engineer or on the requirements of an engineer for a particular job.

Outside Contacts

The nature and extent of the various engineering problems encountered are of such a nature that the average engineer can only hope to do a little in his special line. For this reason contact with what others are doing, the information they have available and the problems they have solved is very desirable. In many cases days of work could be avoided if information from another company were available. The interchange of information to some extent is desirable in that it will frequently eliminate duplication of work.

Participation in the activities of technical societies is advantageous for this reason. The societies serve as a place for trading information. The presentation of papers offers the possibility of getting the advantages of discussions, work of others, or it leads to others extending the work to new fields. Perhaps the most important function of these societies is that it affords engineers from various companies or various parts of the country and with mutual interest an opportunity to become acquainted. The discussions between engineers on subjects of mutual interest usually result in both parties getting a new idea or viewpoint that will result in some constructive development or action. What one individual or company develops is small compared with what is being done by all. The contacts through technical societies give an opportunity to become conversant with ideas, work, and developments of others. The participation in the work of the major technical societies will contribute to professional development of the individual as well.

Executive Department

The degree of contact with the executive department will depend on the particular organization form followed. In case an organization similar to Types 2 and 3 is followed, the contact with the executive department should be through the general superintendent. The executive department has the problem of seeing that a proper balance is maintained between the engineering and operating units. With the form of organization shown, there may still be the danger of the general superintendent following the operating unit's suggestions rather than following the organization manual. Except that the executive department must supervise this, their contact need not go any further. In case of a very large organization, supervision of the technical functions of the company (which might include research, engineering and geological or geographical) would be necessary. In this case one of the executives would have this function.

Summary

The engineering functions of an oil-producing company are involved and technical in nature and are many in number. Because of this the supervision of the engineers must be by someone with technical training and ability. Maximum benefits cannot be obtained by placing them under someone without this training and ability. If proper attention be given to engineering matters, the engineering department can probably function to maximum advantage with a minimum of inter-departmental troubles if placed under the production superintendent. This will be true if engineering is made of sufficient importance so that the higher engineering positions offer opportunity and pay equal to equivalent operating positions. A careful setting out of the duties and responsibilities of the various departments is necessary to obtain best results. Furthermore, engineering departments should limit their activities to engineering functions, thereby keeping their number to a minimum, which will ultimately increase their general standing and importance and make possible a higher salary scale.

A Rational Approach To Cathodic Protection Problems

PART 2

by Gordon N. Scott

Consulting Pipe Line Technologist

A photograph and biographical sketch of the writer can be found on page 27 of the May issue of *The Petroleum Engineer* in connection with Part 1 of this article.

USUALLY in a series of measurements along a pipe line the radius is fixed but the depth of cover varies. Time may be saved, therefore, by plotting a curve in which x is given as a function of c, the depth of cover. Thus after c is accurately measured the location of the second electrode is quickly read from the chart.

A very much more valuable practice is to choose x so that the measured or calculated potential difference, $\Delta V_{xh} = V_x - V_h$, is numerically equal to the drop in potential, $\Delta V_{ha} = V_h - V_a$, between the electrode on the surface of the ground directly over the pipe at $x = 0$ and the surface of the pipe or the coating thereon. The value of ΔV_{ha} is not conveniently measured, but ΔV_{xh} is easily determined. Accordingly, we will assume the following fixed relationship:

$$\Delta V_{xh} = \Delta V_{ha} \quad . \quad . \quad . \quad . \quad . \quad (19)$$

From equation (4) (see also equations 8, 9, and 15):

$$\Delta V_{xh} = 0.0063\, a i_{\square}\, \rho \log \frac{b^2 + x^2}{b^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (15)$$

$$\Delta V_{ha} = 0.0063\, a i_{\square}\, \rho \log \frac{b^2}{a\,(2b - a)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (20)$$

from which, by equating equations (15) and (20) and solving for x:

$$x = \frac{b\,(b - a)}{\sqrt{a(2b - a)}} \quad . \quad . \quad . \quad . \quad (21)$$

Thus if the electrode spacing is such as to satisfy equation (19), not only is the current density readily calculated by the more general form of equation (17):

$$i_{\square} = \frac{K\,\Delta V_{xh}}{\rho} \quad . \quad . \quad . \quad . \quad . \quad (22)$$

but from the same measurements, V_a, may be calculated by simple subtraction inasmuch as:

$$V_a = V_h - \Delta V_{ha} = V_h - \Delta V_{xh}.$$

The coefficient K of ΔV_{xh} in equation (22) is calculated by substituting equation (21) in equation (16) and equating to equation (22), whence:

$$1/K = 0.0063\, a \log \frac{b^2}{a\,(2b - a)} \quad (23)$$

Obviously, of course, we may retain the simple current density equation (17) if we wish, as $\Delta V_{ha} = f(\Delta V_{xh})$. We would then proceed in a manner similar to that followed above to express the relationship between the two as a function in b. But the geometrical configuration of the electrodes that satisfies equation (19) is to be preferred as will later become evident. Accordingly, in order to apply equations (21) and (23), curves are prepared in which x and K are plotted as abscissae against the depth of cover, c, which is more convenient than b as c is the quantity measured in the field.

Considerable labor in preparing the curves can be saved by a mathematical device in which equations (21) and (23) are simplified by setting $b = za$, where z is any number, and substituting za for b in the equations. Whence:

$$\frac{x}{a} = \frac{z\,(z - 1)}{\sqrt{2z - 1}} \quad . \quad . \quad . \quad . \quad . \quad (24)$$

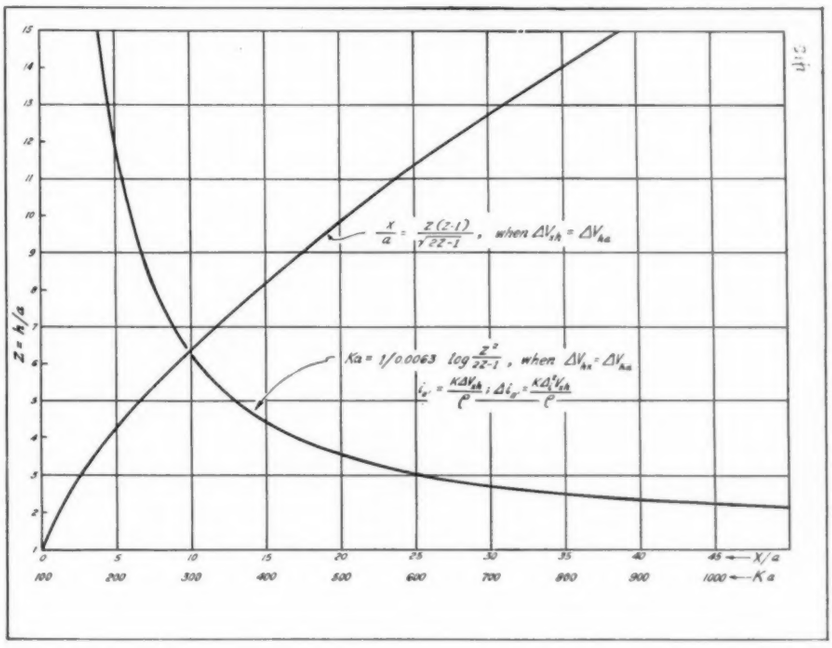
and

$$1/Ka = 0.0063 \log \frac{z^2}{2z - 1} \quad . \quad (25)$$

In Fig. 3, x and K have been plotted in terms of h/a. Once the radius of the pipe line is fixed it is better to prepare from Fig. 3 a separate figure in which x and K are plotted against c as previously suggested in order to avoid the necessity for calculations in the field.

As an example of the use of the several equations we assume, as before, the 10¾-in. pipe with the soil cover of 37.4 in. If $a = 5.38$, then $b = 42.8$ and $b/a = 7.96$. From Fig. 3, $x/a = 13.0$ and $Ka = 255$. Accordingly with one electrode at $x = 0$ (over the pipe line) we set the other $13.0 \times 5.38 = 70.0$ in. to one side thereof. Thus the measured gradient, ΔV_{xh}, is equal to the vertical soil gradient ΔV_{ha} and from

Fig. 3. Ratio of h/a plotted against x/a and Ka, respectively



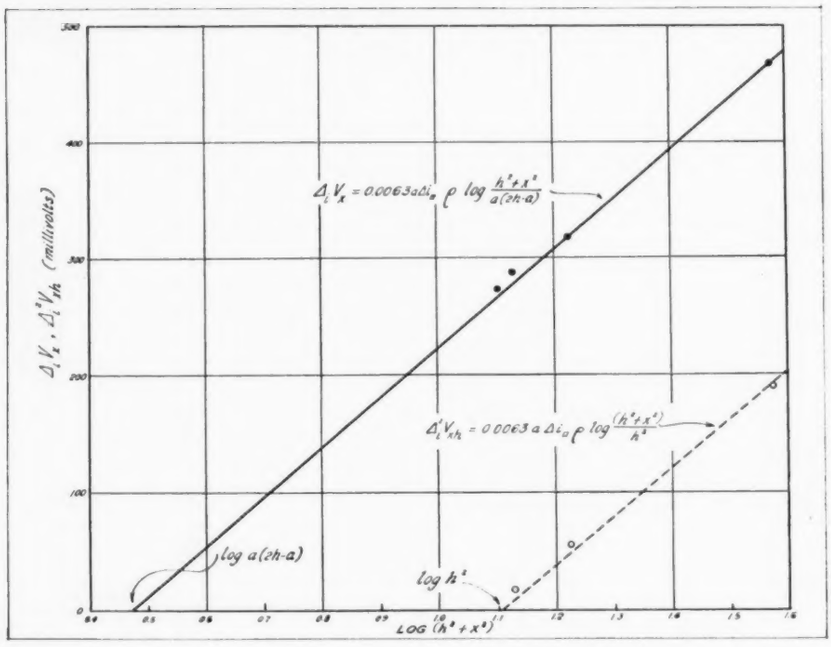

$\Delta_i V_x = 0.0063 a\Delta i_\square \rho \log \frac{h^2+x^2}{a(2h-a)}$
$\Delta^2_i V_{xh} = 0.0063\, a\, \Delta i_\square \rho \log \frac{(h^2+x^2)}{h^2}$
log a(2h-a)
log h²
LOG (h² + x²)
Δ_i V_x , Δ²_i V_xh (millivolts)

Fig. 4. A plot of the data given in columns 4 and 5, Table 1, indicates both lines have identical slopes.

equation (22) we calculate the current density per sq. ft. using a value of $K = 255/5.4 = 47.2$.

Referring to Fig. 2 we note that between $\log h^2$ $(x = 0)$ and $\log (h^2 + x^2)$ where $x = 70/12 = 5.83$ ft., the potential gradient that would have been measured is 270 mv., whence from equation (22), $i_\square = 47.2 \times 270/3000 = 4.25$ milliamp. per sq. ft.

In Fig. 2 we plotted the measured value of V'_x and this procedure, although objectionable in some respects, is convenient in that we do not need to interrupt the external source of current. But unless the external source of current is interrupted much valuable information that might otherwise be obtained would be lost. Thus we see from equation (5), which may be written:

$$\Delta_i V_x = 0.0063\ a\Delta i_\square\ \rho \log \frac{h^2 + x^2}{a'\ (2h - a')} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (26)$$

that the curves of the increments of voltage due to the interruption of $\Delta i = \alpha \Delta I$ when plotted against the corresponding logarithms of $(h^2 + x^2)$ will intercept the logarithmic axis at logarithmic values of a' $(2h - a')$ as the case may be providing that $\Delta_i\ V_a = 0$. The potential increments due to the current are free of electrode potentials but unless the interruption in I is very rapid ΔV_a may not be zero.

In addition to the above current increments we may calculate increments due both to current and to geometrical differences. Referring to equations (6) and (15):

$$\Delta^2_i V_{xh} = 0.0063\ a\Delta i_\square \rho \log \frac{h^2 + x^2}{h^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (27)$$

The intercept of the curve of equation (27) occurs at $\log h^2$.

In Table 1 calculated values of $\Delta_i V_x$ and $\Delta^2_i V_{xh}$ are given in columns 4 and 5. It is quite evident that the first of these values could have been measured directly as could have the increments $\Delta V'_{xh}$ not given. Both sets of these data are plotted in Fig. 4 in which the slopes of the curves must obviously be the same and where the curves differ only with respect to their intercepts on the logarithmic axis. In the one case the intercept occurs slightly to the left of the value $\log a(2h - a)$ showing that there is little or no drop in potential at the surface of the pipe through either rust scale or coating.

Similar curves in $\Delta_i V_x$ are shown in Fig. 5 and in all these cases the pipe was coated. The data from which curves 320 and 616 were prepared are given in Table 2. Additional curves in the series of measurements of which 320 and 616 are representative are also shown in the figure as curves 319, 326, and 350. To avoid confusion the data are not plotted in the last mentioned three curves.

None of these curves intercepts the logarithmic axis at values corresponding to $a(2h - a)$ as the pipelines were coated, but the intercepts do correspond to value of a' $(2h - a')$. Accordingly, if the logarithmic intercept is B, then a' may be calculated, as is readily seen, from the following algebraic expression:

$$a' = h - \sqrt{h^2 - 10^B} \quad . \quad . \quad . \quad (28)$$

At the point on the surface of the coating, $a_t = a + t$, $\Delta_i V_t = \Delta^2_i V_{ta'}$ is the potential drop through the coating, hence the resistance of the coating can be easily calculated once the current density is determined.

From the figure the slope of curve 616 is found to be 62.4 and h/a is 1.875, which is too small a value to permit a determination of Ka from the curve in Fig. 3. But from equation (25) and the pipe radius, $a = 5.57 \times 12$ in., we find $K = 22.1$ whence $\Delta i_\square$ from equation (22) is found to be 0.252 milliamp. per sq. ft. Thus the coating resistance $\Delta^2_i V_{ta'}/\Delta i_\square = 32/0.252 = 127$ ohms per sq. ft. The value of $\Delta^2_i V_{ta'}$ is read from the appropriate curve in the figure and its value for other curves is indicated in the figure in several cases.

The values of:

$$\Delta^2_i V_{xh} = \Delta V'_{xh} - \Delta V_{xh}$$

in Tables 1 and 2 are plotted as dotted curves in Figs. 3 and 5, respectively. The curves intercept the logarithmic axis at h^2, a fact that is of great assistance in determining the slope. Furthermore, curves of these quantities can be drawn on a larger scale, which is of course convenient in determining the slope.

Assuming the pipe to be coated, the two following equations express the components of the measured potential, V_x, due to galvanic currents, and V'_x, the comparable values when the external current source is "on":

$$V'_x = \Delta V'_{xh} + \Delta V'_{ht} + \Delta V'_{ta} + V'_a \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (29)$$

$$V_x = \Delta V_{xh} + \Delta V_{ht} + \Delta V_{ta} + V_a \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (30)$$

In either of these equations we can, of course, measure V_x. We can also measure ΔV_{hx} and, as has been seen, by adjusting x so that $\Delta V_{hx} = \Delta V_{ht}$ the value of ΔV_{ht} becomes known. In neither case, however, do we know $\Delta V_{ta'}$ (the drop through the coating) nor V_a as this latter measurement depends upon the extent to which polarization has occurred and the potential of the half-cell used as a reference electrode. Relying upon the conventional relationship: $V_x - \Delta V_{ht} = V_h$ we may substitute these values in equation (30) and make a similar substitution in equation (31). Furthermore, as it is evident that:

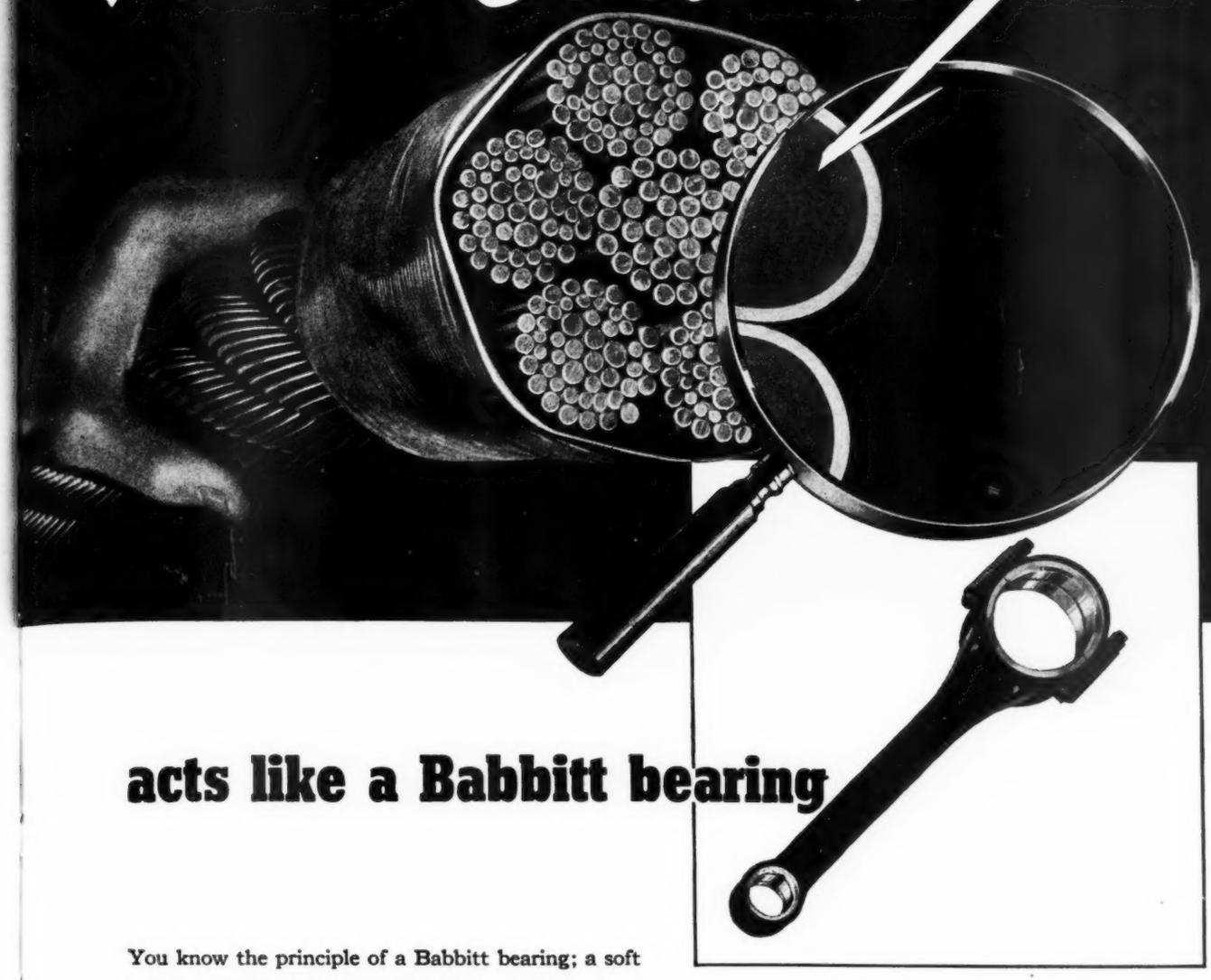
$$\Delta^2_i V_{ta} = \Delta V'_{ta} - \Delta V_{ta}$$

we may, by subtracting equation (30) from equation (29), obtain:

$$\Delta^2_i V_{ta} = \Delta_i V_h - \Delta^2_i V_{xh} \quad . \quad (31)$$

In deriving equation (31), which with a little consideration could have been written at sight, we have assumed that the readings involving a change in i

This Coating...



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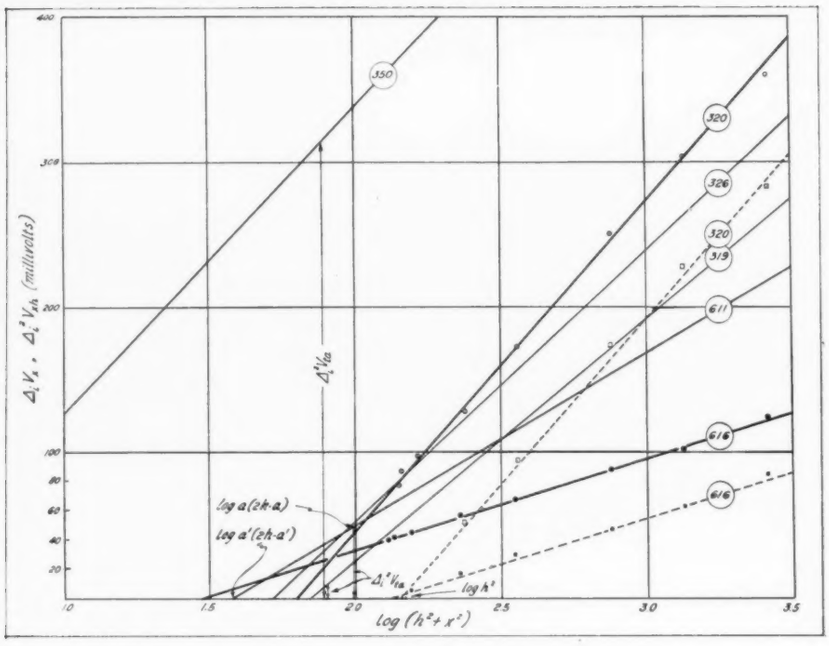

Fig. 5. A group of curves representing coated pipe lines

may be made quickly enough so that no change in polarization V_a occurs during the brief interruption or application of the current. We saw in Table 1 that strictly $\frac{dVa}{di} \neq 0$ but this limitation is easily avoided in this case as only the one measurement $\Delta_i V_h$, in which the above possible error is important, is to be made. The second derivatives or increments on the other hand are independent of variations in V_a under normal conditions of test. This same independence is tacitly assumed in the measurement of any of the changes of potential due to increments of current.

In equation (31) obviously $\Delta_i V_h$ is readily measured. Furthermore, $\Delta^2_i V_{xh}$ is also readily calculated from suitable measurements and it is immaterial what type electrodes are used in the measurements as we are not concerned with electrode potentials nor do we care if the electrodes agree in potential or are even unalike, as all errors are automatically cancelled in the process of measurement.

Inasmuch as two of the three quantities in equation (31) can be found, the drop through the coating, $\Delta^2_i V_{ta}$, caused by the change in current, $\Delta i_\square$, can also be found. The value of $\Delta i_\square$ is calculated by the equation:

$$\Delta i_\square = \frac{K \Delta^2_i V_{xh}}{\rho} \quad . \quad . \quad . \quad . \quad (32)$$

by a process of reasoning similar to that by which equation (22) was derived from equation (15). This was the true relationship used in calculating the current density from the curve 616 in Fig. 5. Comparison of equations (15) and (27) show that K in equation (32) is identical with K in equation (22) and accordingly the relationships of Fig. 3 are applicable in determining K in this instance.

The foregoing gives the experimental and arithmetical procedure by which the coating conductance may be determined. The potential drop through the coating can of course be calculated once the quantities, i, ρ, and a' have been determined and several methods have already been given whereby each of these quantities may be measured. As was shown $\Delta V_{ta} = \Delta V_{aa'}$, hence:

$$\Delta V_{ta} = 0.0063 a i_\square \rho \log \frac{a(2h - a)}{a^1(2h - a^1)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (33)$$

The equation and the outlined procedure ignores the possible *ir* drop, if any, through the polarization film.

The general discussion above may seem confusing to the reader and for this reason Table. 3 is presented in which the several measurements and steps leading to the calculation of the conductance of the coating and the "radius" coefficient are shown in detail. The measurements were made on a 28-in. pipe line.

TABLE 2

Potential* profiles on coated pipe line

x (ft.)	Station 616		Station 320	
	$\Delta_i V_x$	$\Delta^2_i V_{xh}$	$\Delta_i V_x$	$\Delta^2_i V_{xh}$
0	40.2	0.0	76.65	0.0
2	40.75	0.55	86.95	10.3
5	44.5	4.3	97.40	20.7
10	57.0	16.8	128.0	51.3
15	66.75	26.55	172.5	93.5
25	87.5	47.3	248.8	172.0
35	102.0	61.8	303.8	227.1
50	124.1	83.9	359.0	282.3

*Potential differences are in millivolts.

In column (2) of Table 3 is given the resistivity of the soil in ohm-centimeters. In columns (3) and (4) are the measured potentials in millivolts at $x = 0$ with the external current source in effect and interrupted, respectively. In columns (6) and (7) are given the measured soil gradients where, by convention, the value of x is such that $\Delta V_{xh} = \Delta V_{ht}$, again with the external current source "on" and "off". These are the measured quantities.

In columns (5) and (8) of Table 3 are the calculated differences in the potentials, $\Delta_i V_h$, and gradients $\Delta^2_i V_{xh}$ obtained by subtracting the "off" reading from the "on" reading with due regard to sign. As noted above, the spacing x of the electrodes was fixed so that the surface gradients are so fixed as to be numerically equal to the *ir* drops in the soil along the vertical axis; consequently, the algebraic difference between the figures in columns (5) and (8) is the potential drop through the coating, $\Delta^2_i V_{ta}$, given in column (9). Now from the known measured depth of cover, not given, and the corresponding value of K taken from Fig. 3 and given in column (10), the current density, $\Delta i_\square$, is calculated by substituting [in equation (32)] the associated values of K and the gradient differences in column (8). The calculated current density, due only to the external current source and "tagged" as it were, is given in column (11). The coating resistance, R_c, $\Delta^2_i V_{ta}/\Delta i_\square$), appears in column (12). The ratio, R_c/ρ, is given in column (13) and a', calculated by equation (12) and reported as the radius coefficient a'/a, is given in column (11).

The data in columns (13) and (14) are plotted in Fig. 6. Also in this figure appears a curve for comparison showing the more or less general relationship between the radius coefficient and the "coating resistance-soil resistivity ratio" as calculated from equation (12) slightly modified as shown in the figure to be in terms of a'/a and h/a for 10¾-in. O.D. pipe where h/a is assumed to be 6. Thoughtful consideration of equation (12) will show that the radius coefficient a'/a is relatively insensitive to variations in the depth of cover but is critically responsive both to the soil resistivity and the coating conductance.

The curve approaches $a'/a = 0$ asymptotically and, at the ratio of $R_c/\rho = 0.05$, is already substantially zero, for a 10¾-in.O.D. pipe. At this value the coating conductance is 20,000 micromhos per sq. ft. in a soil of

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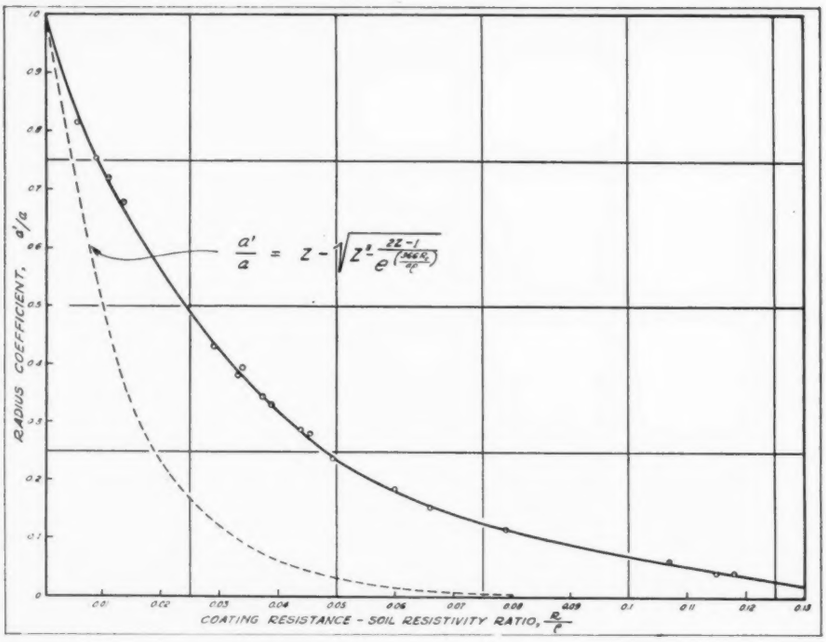

Fig. 6. Graph of relationship of a'/a and R/ρ

resistivity of 1000 ohm-cm. and only 4000 micromhos per sq. ft. in a soil of 5000 ohm-cm. resistivity.

For values of $R_c/\rho > 0.05$ the usual criterion of protection of a copper-sulphate reading of 0.80 to 0.90 v. no doubt applies satisfactorily as a criterion of protection but for values of $R_c/\rho < 0.05$ it is quite probable that no such simple rule is applicable. Reasons for this are partly obvious in that the soil gradients, particularly in the higher resistivity soils, may constitute a substantial portion of the reading. Partly obscuring this point, however, is the fact that polarization on the pipe surface is linked to certain physical and chemical properties of the soil. The value of $R_c/\rho = 0.05$ is also approximately the limit of satisfactory gradient measurements.

The inadequacy of the fixed "copper-sulphate reading" as a criterion is quickly realized when consideration is given to the relationship derived below. The potential drop through the coating, ΔV_{ta}, is equal to the coating resistance times the current, or, isolating the current, $i_\square$:

$$i_\square = \frac{\Delta V_{ta}}{R_c} \quad . \quad . \quad . \quad . \quad . \quad . \quad (34)$$

Substituting this equation in equation (16) where $\Delta V_{zh} = \Delta V_{ht}$ and rearranging:

$$\frac{\Delta V_{ta}}{\Delta V_{ht}} = \left(1/0.0063\ a \log \frac{x^2 + b^2}{b^2} \right) \frac{R_c}{\rho} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (35)$$

Thus the ratio of the potential drop through the coating to the vertical soil gradient is directly proportional to the "coating resistance-soil resistivity ratio." A few calculations will suffice to show the reader the distribution and importance of the soil and coating gradients in their relation to any arbitrary "copper-sulphate reading".

Although there may be a certain sense of security in employing the mentioned rule of thumb criterion because the above arbitrary resistance ratio limit, R_c/ρ, is so small, reference to the conductances of the A.P.I. Test Coatings[7,8] will show that a large percentage of the coatings gave conductance-resistivity products, $C_c\rho$, greater than 2×10^7, which is the arbitrary criterion in terms of coating conductance in micromhos per sq. ft. and soil resistivity in ohm-centimeters.*

[7] "Progress Report No. 4, Third Inspection of Pipe Coating Tests on Operating Lines and Second Inspection of Short Coated Specimens," by Gordon N. Scott. *A.P.I. Proceedings 15* (IV), 18, (1934).

[8] "Report No. 5, Fourth and Final Inspection of Pipe Coating Tests on Operating Lines and Third and Final Inspection of Short Coated Sections," by Kirk L. Logan. Paper presented at A.P.I. annual meeting, Chicago, Illinois, Nov. 14, 1940.

*The writer has preferred to use units in common use even though, for example, centimeters and inches may thus occur in a single expression.

EDITOR'S NOTE: This article will be continued in an early issue of *The Petroleum Engineer.*

TABLE 3
Measurements and calculations of coating resistance and other quantities

Col. no..	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Test no.	ρ	V'_h	V_h	$\Delta_i V_h$	$\Delta V'_{zh}$	ΔV_{zh}	$\Delta_i^2 V_{zh}$	$\Delta_i^2 V_{ta}$	K	$\Delta i_\square$	R_c^*	R_c/ρ	a_1/a
1	1900	— 508	—495	— 13	— 11.5	— 5.1	6.4	6.5	29.5	0.101	64.4	0.0339	.383
2	2200	— 543	—395	—148	— 16.8	— 9.5	7.3	141	28.5	0.094	1500	0.672	0.000
3	2500	— 545	—400	—145	— 54.7	—26.1	28.6	116	25.0	0.286	405	0.162	0.027
4	800	—1045	—435	—610	— 67.3	—21.8	45.5	564	45.5	2.07	272	0.340	0.001
5	1200	— 468	—400	— 68	— 24.7	— 9.4	15.3	527	27.5	0.350	1500	1.249	0.000
6	2100	— 422	—358	— 64	— 10.4	+18.2	39.2	24.8	78.5	1.48	11.8	0.0057	0.814
7	1600	— 398	—350	— 48	— 23.7	—12.5	11.2	36.8	30.5	0.215	171	0.1068	0.062
8	2300	— 385	—358	— 27	— 27.8	—16.4	11.4	15.6	31.0	0.154	101	0.044	0.287
9	1800	— 384	—352	— 32	— 36.9	—26.6	10.3	21.7	35.5	0.202	108	0.060	0.186
10	600	— 482	—414	— 68	— 97.5	—23.3	74.2	.....	36.5	4.52	.....	.....	0.000
11	900	— 500	—382	—118	— 66.6	—14.3	52.3	65.7	28.5	1.60	41.0	0.0455	0.280
12	1800	— 642	—365	—277	—144.8	—13.6	131.2	146	28.5	2.08	70.0	0.0390	0.331
13	1500	— 396	—340	— 56	— 48.9	—12.0	36.9	19.1	46.5	1.15	16.6	0.011	0.720
14	1500	— 422	—342	— 80	— 49.4	—14.0	35.4	44.6	37.5	0.885	50.5	0.0337	0.369
15	1300	— 480	—442	— 38	— 39.6	—29.7	9.9	28.1	43.0	0.328	85.7	0.066	0.154
16	1500	— 410	—398	— 12	— 51.9	—43.2	8.7	3.3	41.5	0.241	13.7	0.0091	0.752
17	1200	— 437	—408	— 29	— 9.3	— 2.5	6.8	22.2	28.5	0.161	138	0.115	0.041
18	2500	— 568	—538	— 30	— 19.0	— 4.0	15.0	15.0	33.5	0.205	73	0.0292	0.430
19	6200	— 490	—368	—122	— 29.1	—16.6	12.5	109.5	43.0	0.087	1260	0.203	0.004
20	600	— 950	—605	—345	— 62.3	+ 8.1	69.4	276	32.5	3.76	70.8	0.118	0.041
21	1600	— 490	—346	—144	— 46.7	—24.4	22.3	122	32.0	0.446	273	0.171	0.010
22	6500	— 402	—352	— 50	— 28.0	— 5.2	22.8	27.2	32.5	0.112	243	0.0373	0.343
23	3600	— 435	—408	— 27	— 6.5	+ 2.6	9.1	17.9	25.0	0.063	284	0.0788	0.117
24	3600	— 358	—336	— 22	— 39.4	—23.8	15.6	6.4	30.5	0.132	48.5	0.0135	0.682
25	3800	— 335	—308	— 27	— 33.4	—22.8	10.6	16.4	31.0	0.087	188.0	0.0495	0.239

*Ohms per sq. ft.

LEFT—Ted Sutter, national president of the Nomads, was honor guest at a banquet presented by the International Petroleum Exposition for Nomads club members from the Houston, Los Angeles, New York, and Tulsa chapters during the Mid-Year A.P.I. meeting in Tulsa. Awards were made for service rendered by the four Nomads chapters in caring for international delegates to the 1940 Exposition. Left to right: Rex Hamaker, who received the award for the Houston Chapter; E. L. Decker, past national president, who received an award for his personal services; Fred E. Cooper, who accepted the award for the Tulsa Chapter; Sutter; M. E. Montrose, who received the award in behalf of the Los Angeles Chapter; George Eichler, represented the New York Chapter; Ray Dudley, Houston Chapter, and L. D. Baird, regent of the Tulsa Chapter.

ABOVE—The banquet given at the recent Mid-Year Meeting of A.P.I., Tulsa, Oklahoma, by International Petroleum Exposition for members of the Nomads was well attended. W. G. Green, president of the Tulsa Chapter of Nomads, was toastmaster.

RIGHT—Newly elected officers of Petroleum Industry Electrical Association. Left to right: C. O. Diller, Lone Star Gas Company, president; L. G. Wainman, El Paso Natural Gas Company, vice-president, and J. F. Collerain, Houston Pipe Line Company, secretary.

BELOW—Annual banquet of Petroleum Industry Electrical Association, held during convention of association in Tulsa, Oklahoma.

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When Samuel M. Kier put his product on the market one hundred years ago he little dreamed that some day "Rock Oil" would be good for something more than "A natural remedy for human ills." The reproduction above is from Dr. Kier's descriptive booklet published in 1840.

This spectacular gusher is the Heywood No. 2 of Magnolia Petroleum Company at Beaumont, Texas, in 1901. It filled four 50,000-barrel tanks in 24 hours.

This group of pictures of early-day oil scenes will be of interest to many because, in addition to their human interest, they depict graphically the progress that has been made by the industry in relatively few years. Some of the men appearing in the photographs are still active and there are many others who will recall the places and events shown, having themselves been present at such oil booms as Spindletop, Smackover, Ranger, etc. The pictures are made available through the courtesy of the Magnolia Petroleum Company.

Eighteen oxen struggled to pull this heavy piece of oil-field machinery over the Missouri Pacific Railroad tracks in Smackover, Arkansas, in 1922.

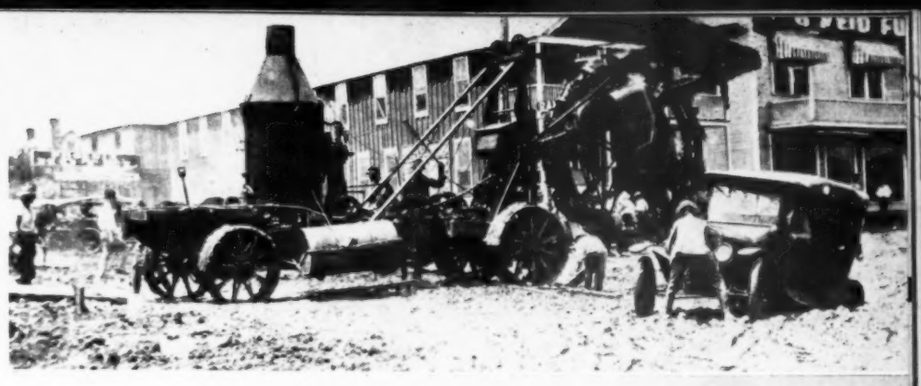
Part of the famous Spindletop field at Beaumont in 1901. This field was the first "big" oil field in Texas.

Celebrating the birth of the Texas oil industry at Corsicana, the Texas Mid-Continent Oil and Gas Association presented a memorial plaque to the citizens of Corsicana. Here is E. L. Smith, association president, inspecting the plaque mounted on a scale derrick erected just south of the city.

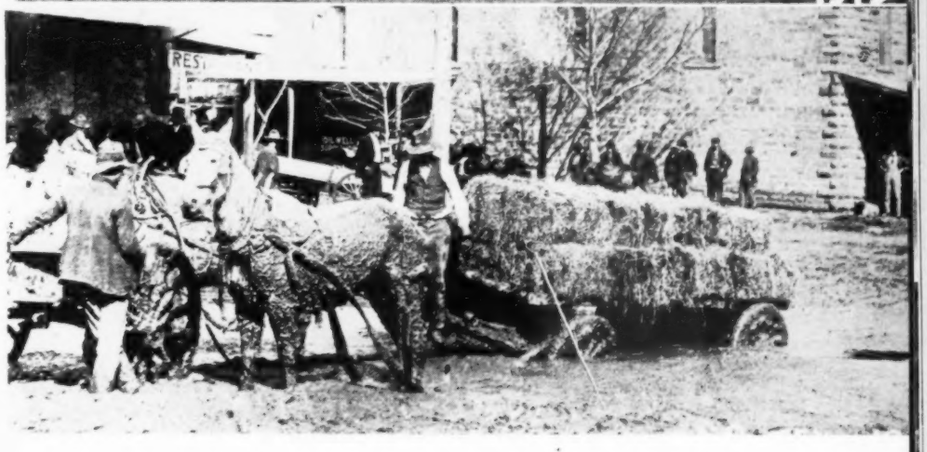
The plaque reads:

Birthplace of the Texas Oil Industry
First Important Oil Field in Texas Opened here Oct. 15, 1895.
First Successful Refinery in Texas Completed Christmas Day, 189[illegible]

The forerunner of all present-day drilling rigs was the spring pole outfit, such as the one shown above. In the early days of the Volcano field all wells were drilled by the spring pole method.



Before adequate fire-fighting equipment was available, major oil companies maintained a small cannon, such as shown here, and a gun crew. When a tank of oil caught fire a shot was fired into the base of the tank, allowing the oil to drain, minimizing the extent of the fire and saving a part of the oil.

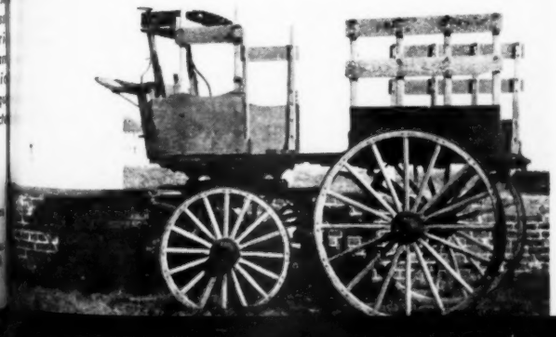


Were you in Ranger? Most oilmen who were got pretty tired of the mud.

Twenty years ago in Drumright, Oklahoma. This is a picture of a drilling deeper job taken in the spring of 1921 at the S. W. Dix No. 1 well of Magnolia Petroleum Company. From left to right are: John S. O'Brien, who was a driller at that time; E. D. Smith, the district's superintendent; Frank Nelson and Harry Jones, who were drivers of the White trucks, which were then ultra-modern transportation equipment.

An old well in the Shamburg District, Pennsylvania. The engine used to pump wells was installed on the property adjoining this lease.

This old stake wagon powered by a team of dependable "hay burners" was one of the first delivery vehicles put in service by the Corsicana agency of Magnolia Petroleum Company. The wagon is still preserved at Magnolia's Corsicana refinery.



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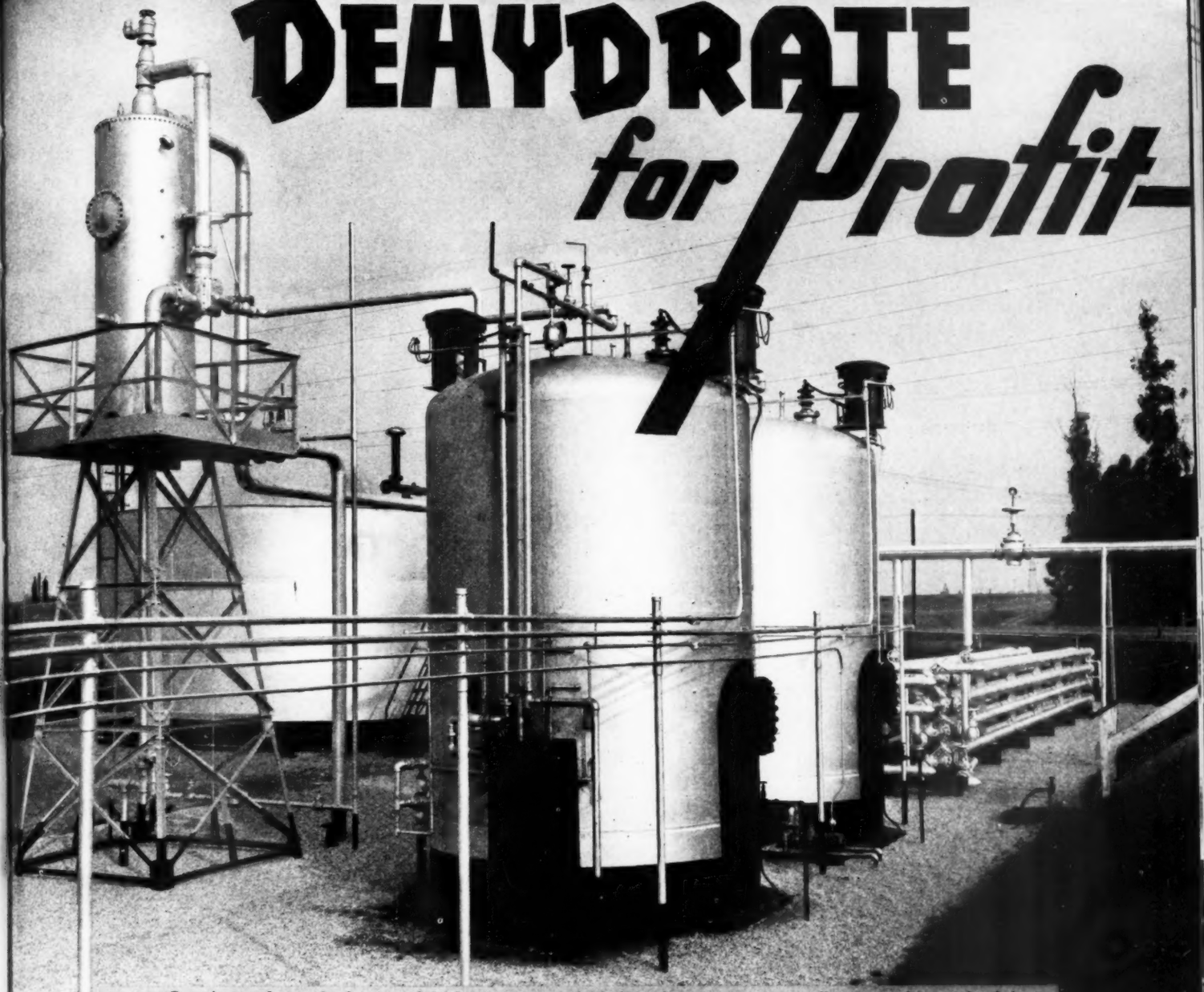

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DEHYDRATING DE-SALTING

Estimation of Underground Reserves of Petroleum[1]

PART 2

by B. B. Bilibin

REFERRING to Fig. 1,* in the squares of the body of the chart are plotted actual well data in the form of circles. Such a correlation chart is subject to careful geological-technical analysis from the point of view of investigating individual "points" that are beyond the range covered by the chart. By means of this analysis, those factors that must be considered in the following described construction of curves (difference between the initial yields of wells in different reservoirs) are clarified and also those data are excluded that are accepted as being insufficiently accurate or obviously incorrect.

The relationship between variables x, y and z (and, therefore, the accuracy of the calculation of the curves of their relationship) is determined by means of the chart, as are curves showing the relationship of y to x (or more correctly the relationship of log y to log x) for the same interval of variable z. As a result, a series of curves is obtained; these curves are smoothed out to eliminate all incidental influences by the method of least squares to give the best theoretical curves satisfying the selected equation, $y = AB^x$.

The distance-time curves constructed in this manner permit calculating the probable initial yield of an oil well as dependent upon the state of development of the given formation as well as upon the subsequent program of additional drilling.

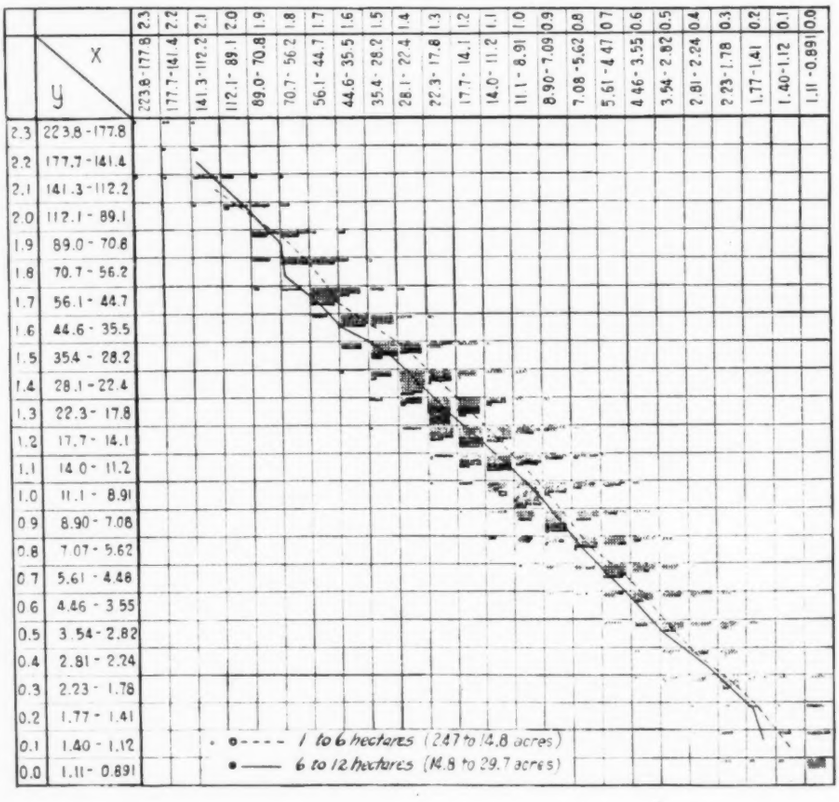
As will be noted from the above, the oil that may be expected to be recovered from a given formation may depend upon the density of drilling and the rate of development. If this fact is established by constructing distance-time curves and computing the coefficient of decline of production then, when calculating the reserve of oil, account is taken of the plan of development for each horizon.

Such is the method of constructing curves of the relationship between the initial yield of oil wells and other factors. A similiar method is used for calculating the probable rate of decline of an oil well. An index of the decline of production of an oil well is the percentage decrease or so-called coefficient of decrease, which is the ratio of the production of the second month of a well's producing life to that of the preceding or initial month. The index for a well or group of wells, and the initial productions depend upon the characteristics of the reservoirs and the distance between wells (well spacing).

To show the relationship between the initial production of a group of wells and the well spacing, correlation charts are used on which curves are drawn to show the value of the coefficient of decrease. Such charts show that the higher the initial yield, the greater the rate of production decline; they show also that the denser the wells (the smaller the number of hectares or acres per well) the more rapid is the rate of decline of production. The data used in constructing the correlation charts are the average daily yields of the oil wells by months and the areal extent of the free area about the well at the time it is brought in. On the correlation chart, Fig. 2, the average daily production for each consecutive month is taken as variable x; the average daily production for the preceding month is variable y, and the density of drilling in hectares per well is variable z.

The logarithms of variable x occupy

Fig. 2. Correlation chart showing the relationship between the average daily production of wells for one month and for the preceding month for two-well densities. Data from Bay of Baku field, VII horizon



[1]Translated from the Russian Geological Journal, *Problemy Sovetskoi Geologii* (Problems of Soviet Geology) 6, 1936, pp. 34-43, 133-196, by A. A. Boehtlingk, publisher of *Foreign Petroleum Technology*, Berkeley, California.

*See Part 1, May issue.

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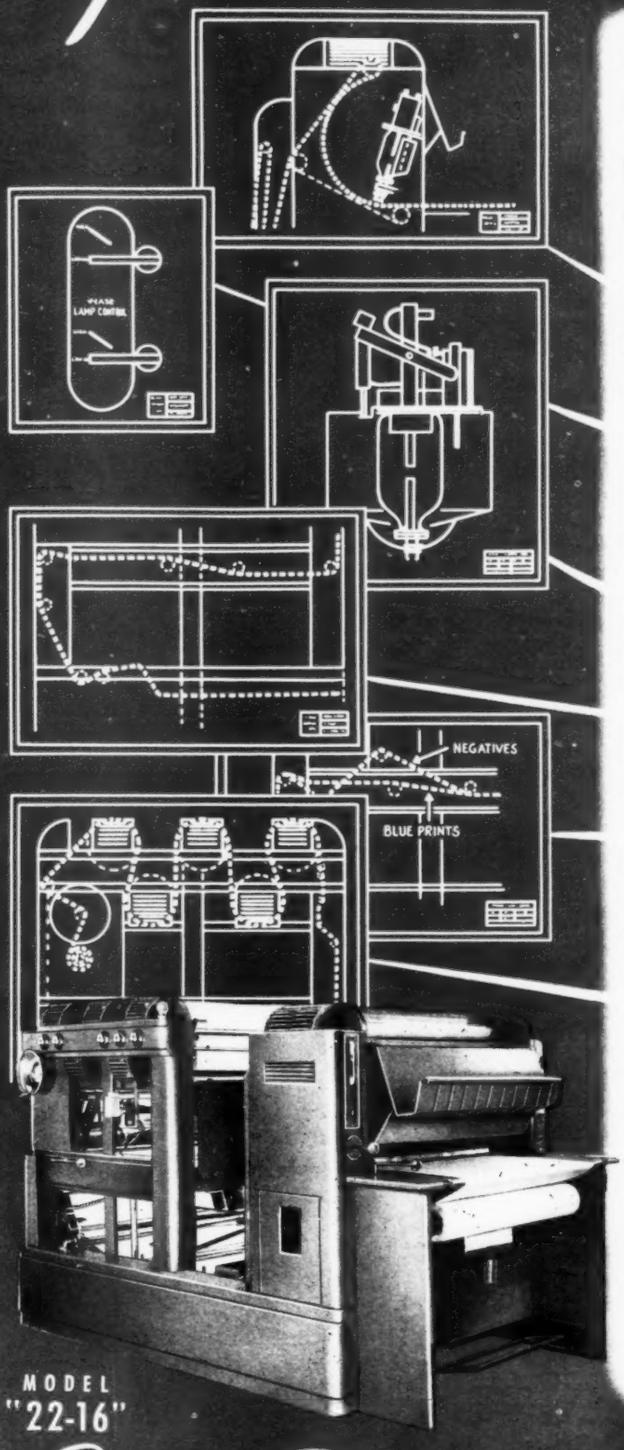

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TABLE 3
Coefficient of decrease of production, K

Current production of oil		Density of wells, { hectares per well / acres per well		
tons	bbl.*	1 to 3 2.47 to 7.41	3 to 6 7.41 to 14.8	6 to 9 14.8 to 22.2
Greater than 200	Greater than 1300	0.750	0.780	0.795
200–50	1300–325	0.820	0.830	0.850
50–14	325– 91	0.860	0.925	0.950

*Based on 1 ton = 6.5 bbl.

the squares along the abscissa axis; variable y similarly is divided into equal logarithmic intervals and occupies the squares along the ordinate axis. After plotting values of y in the body of the chart for corresponding values of x, using different symbols for different intensities of well density (in Fig. 2), variable z is divided into two groups, 1 to 6, and 6 to 12 hectares per well, respectively. Average lines are drawn through the plotted points to show, for different group values of variable z, the relationship between x and y. Usually the influence of well density z on the rate of decline of production is noticeable only if z is divided into relatively large groups. The open circles on Fig. 2 represent values of y for corresponding values of x when the density of wells is between 1 and 6 hectares per well; the filled-in circles show the relationship when the density is between 6 and 12 hectares per well, and the average lines representing the two values of variable z show the influence of y on z.

After the best average line representing variable z has been drawn through the plotted points for x and y, the coefficient of decrease is determined by subtracting log y from log x. Thus, if x equals the average daily oil production of a group of wells for a given month and y equals the average daily yield for the preceding month, the ratio $\frac{x}{y}$ will be the coefficient of decrease K. As the chart scales are logarithmic values of x and y, however, $\log K = \log \frac{x}{y}$ or $\log K = \log x - \log y$. The antilogarithm of the value of log K, therefore, is the value of the coefficient of decrease.

From data taken from a chart similiar to that shown as Fig. 2, Table 3 is offered as an example to show the value of the coefficient of decrease as related to the current oil production and to the area (free area) alloted each well.

Coefficients of decrease, K, are used in estimating the total yield of the new wells based on their probable initial yield as determined from distance-time curves as well as in the calculation of the residual yield of wells already producing (on the basis of their current production rates at the time the calculations are made). For calculating the reserves in an area that is planned to be drilled to its maximum density only that line in the graph that relates to the coefficient of decrease at the maximum density of drilling is used. Thus, the data shown on the graphs are used to calculate the reserves remaining unrecovered in areas undergoing depletion by applying the proper coefficient of production decline; for calculating probable reserves the distance-time curves are used to calculate the probable initial yield of the wells to be drilled, and by using the coefficients of decline their total yield can be calculated[3]; and possible reserves are calculated by using the curves constructed for developed areas and calculating the reserves by analogy.

It should be noted that the construction of the abovementioned curves for a large number of oil-bearing formations will permit one to segregate the formations on the basis of their natural characteristics and the properties of the oil, which together form a basis for the adoption of the method of curves by analogy for those formations and for parts of formations on which insufficient data have been collected to construct curves but for which the natural properties are known or can be assumed with reasonable accuracy. Data on the production of wells and individual formations can be analyzed only when the data reflect the normal yield of the formations at the time of their exploitation and the suggested curves cannot be constructed if the data are abnormal or if the construction of the curves is attempted on the basis of insufficient field development. Incidentally, the correlation charts will reveal the absence of required data and will show that it is impossible to construct the curves.

[3]In the calculation of total yield, a given minimum production is assumed as the economic limit of yield.

Volumetric Method

The following equation is used in calculating oil reserves by the volumetric method:

$$S = V\,d\,a\,b\,c$$

when

S = total oil that may be recovered from a pool, tons

V = volume of the oil-bearing reservoir, area times thickness

d = density (sp. gr.) of the oil

a = coefficient of porosity

b = coefficient of saturation

c = coefficient of recovery.

By substituting actual figures (based on records of depleted reservoirs) for V, d, and a, which are known, the value of bc may be determined by using the following transformed form of the above equation:

$$bc = \frac{S}{Vda}$$

Inasmuch as b and c cannot be calculated separately from field data, it is assumed in the calculation of oil reserves by the volumetric method that bc equals x, the coefficient of utilization. The equation then may be written:

$$S = Vdax$$

When this equation is used in the

TABLE 4
Coefficients of utilization for different reservoir conditions

Pressure of edgewater	Volume of gas dissolved in the reservoir oil	Permeability of the oil-producing formation	Coefficient of utilization[1] (coefficient of saturation times coefficient of recovery)	Producing operations yielding maximum recovery
High	Unusually large	High	0.8 to 0.9	Proper control of edgewater
Not very high	Large	High	0.6 to 0.8	Proper control of edgewater and efficient gas-oil ratios.
Not very high	Not very large	Average	0.4 to 0.6	Proper control of edgewater and efficient gas-oil ratios.
Very low	Large	Any	0.3 to 0.4	Efficient gas-oil ratios
Very low	Not very large	Any	0.2 to 0.3	Efficient gas-oil ratios.

[1]For heavy, viscous oils, the coefficient of utilization will be less than shown in the table.

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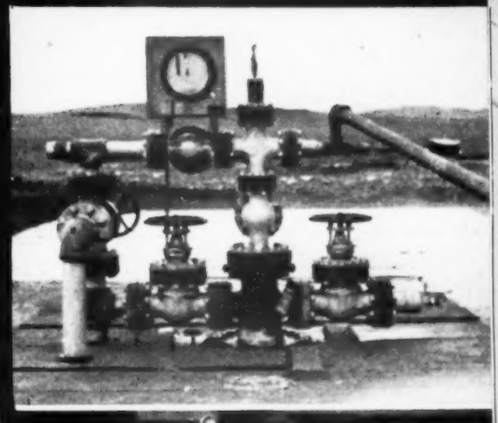

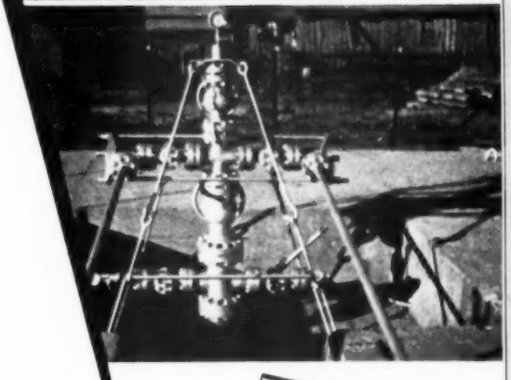

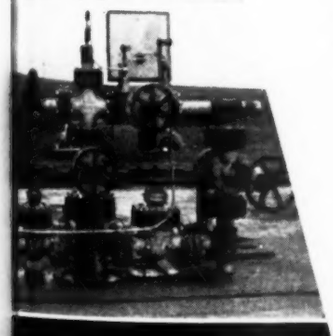

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calculation of reserves, each factor in the equation cannot be set down as having a definite value but must be defined between maximum and minimum limits. Because of this fact, reserves estimates then will be calculated as being between certain limits such as say 2 to 3 million tons, or as being a reserve of 30 to 40 million tons, a difference that may be considerable but nevertheless within the limits of accuracy of the calculations.

As will be noted from the following discussion, the accuracy of the calculated values of each factor in the equation, the accepted limits of the coefficient of utilization, and the area of the oil deposit depend upon the completeness of field data so that, by accepting relatively wide limits when calculating reserves, some of the inaccuracies of the factors will compensate and the final reserve figure will be within narrow limits.

Determining Coefficient of Utilization

The most difficult step in the calculation of underground oil reserves by the volumetric method is the determination of the coefficient of utilization (coefficient of saturation times the coefficient of recovery). Theoretical methods for arriving at a representative coefficient of utilization do not yield dependable results and the best method is to base the coefficient on the production history of reservoirs that have been depleted of their recoverable oil. A coefficient of utilization so determined can be used with reasonable assurance of accuracy in the calculations of reserves in new areas.

As the volume of oil-depleted reservoirs, the specific gravity of the oil, and the porosity of the oil-bearing formations are known, the coefficient of utilization can be determined by substituting known values for the symbols in the equation:

$$x = \frac{S}{V\,da}$$

The ultimate recovery of oil from reservoirs not completely depleted of their recoverable oil can be determined by adding their future production, as estimated by means of production-decline curves, to the quantity of oil already produced. The coefficient of utilization calculated from such data will not be greatly in error because the percentage of oil remaining to be recovered from the greater number of fully developed fields usually is only a small percentage of the total oil that will be recovered ultimately. Small errors in the calculated future production of reservoirs will not, therefore, materially affect the computed coefficient of utilization.

Coefficients of utilization depend in large part upon the "control" in oil-bearing reservoirs—whether the oil is being expelled from the reservoir formations by the expansion of the gas associated with the oil, by a natural water drive, or as a result of a combination of these two expulsive forces. It is necessary, therefore, when evaluating the coefficient of utilization to consider the oil-propelling agent. Gravity drainage also may be a factor in oil recovery but reservoirs in which production depends entirely upon gravity to move the oil to the wells usually have no commercial value. Coefficients of utilization depend, therefore, upon (1) initial pressures in the reservoirs and the sources of the pressure, (2) permeability of the oil-bearing formation, and (3) the physico-chemical properties of the oil. Coefficients of utilization are highest for highly permeable reservoirs that are initially under high pressures with large volumes of gas dissolved in the oil, which is underlain by mobile edgewater under high head. From such reservoirs, large quantities of oil are produced first as a result of gas expansion with large volumes of gas accompanying the oil to the wellheads (a gas cap may form in the reservoir) and later, as pressures in the reservoirs decline, edgewater assumes a major role in oil production. On the other hand, when only small volumes of gas are dissolved in unit quantities of oil in the reservoir initially, early production rates will be lower than for reservoirs in which the oil originally was saturated with gas, and edgewater quickly becomes a factor in oil production. In general, therefore, the intensity of the pressure of the edgewater and the permeability of the oil-bearing formations have a major influence on oil recovery and the efficiency of oil recovery.

Reservoirs in which the pressure of edgewater in high-structure wells builds up slowly because the oil-bearing formations are "tight" will have a low coefficient of utilization even if the initial reservoir pressures were high. Such reservoirs usually yield high initial productions of oil and produce large volumes of gas during their flush producing lives but rates of production and reservoir pressures decline rapidly. If the original reservoir pressures are low and the formations tight, the inherent energy of the gas soon is exhausted, production rates decline rapidly, and because the gas is inefficiently utilized in driving oil through the oil-bearing formations to wells, the coefficients of utilization will be low. It should be borne in mind that coefficients of utilization also will be low in highly permeable reservoirs in which the pressure of edgewater is high unless oil-production rates are controlled so as to prevent fingering and coning of edgewater and the resultant entrapment of otherwise recoverable oil.

The viscosity of the oil flowing through reservoir sands and rocks to wells and probably certain of its other physical properties also have an influence on the percentage of oil recovered from oil-bearing formations, particularly if the oil is very viscous. The more viscous the oil the smaller the coefficient of utilization.

A general idea of the magnitude of coefficients of utilization for different natural reservoir conditions may be gained from the preliminary though manifestly incomplete data given in Table 4.

The data given in Table 4 are based on experience in producing oil in the Apsheron field and more than likely the coefficients of utilization for other fields will differ slightly from those shown. It should be possible, however, from the information given in the table and by giving proper consideration to such factors as the hydrostatic head of edgewaters, permeabilities of the oil-bearing formations, etc., to estimate closely the coefficients of utilization for other reservoirs.

If, based on the best information available, a coefficient of utilization is calculated for developed and partly developed reservoirs, this factor can be used in checking ultimate recoveries estimated by the volumetric method with those determined by means of production-decline curves. To arrive at the probable coefficient of utilization for reserves classed as possible and prospective, it becomes necessary to estimate the coefficient on the basis of a geological and lithological study of the reservoirs. Apparently there is a relationship between the permeability of oil-bearing sands and rocks and their mechanical composition because with an increase in the average grain size there is an increase of permeability, and other conditions being equal, an increase in the coefficient of utilization. Also, for equal average sizes of grains uniform sands have a higher permeability than less uniform sands.

In the calculation of prospective reserves it will be necessary to assume an average coefficient of utilization based on that determined for similar reservoirs. Under those conditions, the coefficient of utilization should not be an arithmetic average value but preferably one based on the most frequently repeated or the most characteristic coefficients.

EDITOR'S NOTE: This article will be continued in an early issue of *The Petroleum Engineer*.

Properties of Hydrocarbons Found in Natural Gas

Exclusive

☆ A practical review of basic organic chemistry centered on natural gas constituents

by Roy W. Machen

Superintendent, Hamman Exploration Company

NATURAL gas, crude petroleum, and the products obtained by the processing of these raw materials are mixtures of hydrocarbons.

Hydrocarbons are essentially chemical compounds composed of carbon and hydrogen. These various compounds are quite unlike in characteristics and the structural grouping of the atoms that make up the molecule determines the series membership of the compound.

The Paraffin Series

The paraffin series (so called because of the stability of various respective members, the term paraffin being derived from the Latin *parum affinis*, meaning little affinity) is composed of hydrocarbons of such structural nature that only singly linked carbon atoms are in the make-up of the molecule. This series is quite often spoken of as the "methane series" because methane, CH_4, is the simplest member of the group.

The valence of an element determines the extent to which one of its atoms will combine with or displace atoms of another kind. As chlorine and hydrogen atoms are capable of combining with only one atom of another kind, they are called univalent atoms and are the standard of valence. The valence of hydrogen is 1, and as one atom of carbon will combine with 4 atoms of hydrogen, any saturated hydrocarbon compound is one in which each carbon atom is combined with 4 of hydrogen or the equivalent thereof.

The paraffins are commonly termed "saturated", "open chain", or aliphatic hydrocarbons. They are characterized by their relative stability and it is principally upon this basis that they are differentiated. Normal compounds under normal conditions do not react with strong acids, alkalies, or oxidizing agents. Although other elements do not unite directly with a saturated compound, they may be substituted for elements already present. As an example, methane, CH_4, when brought in contact with chlorine under suitable conditions, loses one of its hydrogen atoms through displacement by one chlorine atom.

ROY W. MACHEN

received a bachelor's degree from Oklahoma City University in 1927—Employed for six and one-half years by the Peppers Gasoline Company as refinery clerk, refinery and gasoline plant chemist, and gas engineer—Later saw service with various independent refining companies as gas engineer, operator in high-pressure gasoline plants, refinery construction engineer, and superintendent of refinery operations—Now is superintendent for the Hamman Exploration Company—Is a registered petroleum and natural gas engineer.

The general formula for the paraffin series is C_nH_{2n+2}. The letter "n" represents the number of carbon atoms present in the molecule. This series is the most extensive of the several hydrocarbon series. All compounds in the series to $C_{32}H_{66}$ are known.

Normal Compounds

A normal compound is one in which no single carbon atom is linked with more than two other carbon atoms. Methane, CH_4, ethane, C_2H_6, and propane, C_3H_8, are all normal hydrocarbons and there are only single examples of these compounds. There are, however, two compounds that have the same chemical formula, C_4H_{10}, normal or n-butane and *iso*butane; three pentanes, C_5H_{12}; five hexanes, C_6H_{14}; and as the number of carbon atoms increases in the molecule the number of compounds having the same elements in the same proportion and represented by the same chemical formula increases. For instance, there are possibly more than 800 compounds having the same formula as tridecane, $C_{13}H_{28}$.

All members of the paraffin series are insoluble in, and lighter than, water. The specific gravities increase as the molecular weights increase and as the molecular weights increase their boiling points become greater. The heavier members may not be distilled at atmospheric pressure without decomposition. It has been authoritatively stated that the molecular weights at the melting points are nearly proportional to the molecular volumes of the heavier members.

The first four compounds in this series, methane, ethane, propane, and butane are gases at normal atmospheric temperature and pressure. Compounds having from 5 to 16 carbon atoms are liquids, and those containing more than 16 carbon atoms are solids.

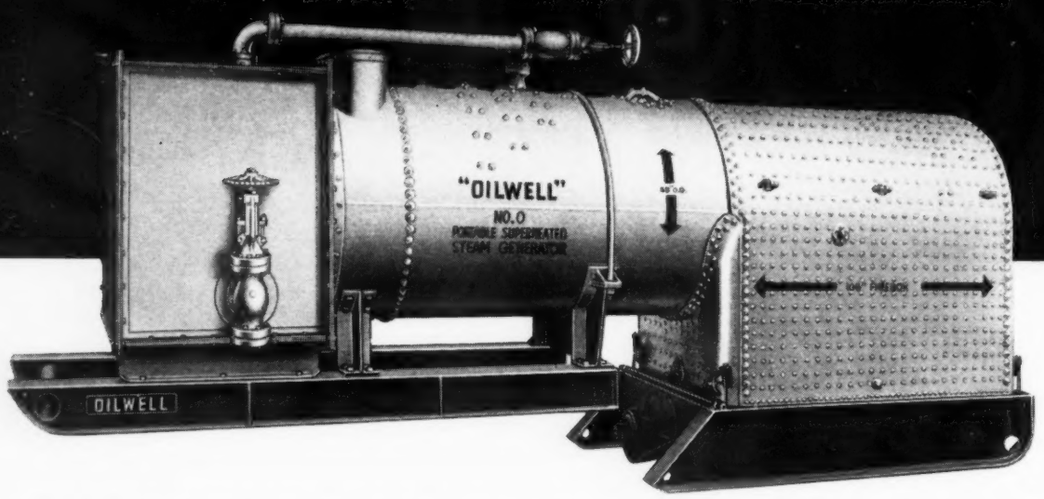
Natural Gas

The hydrocarbons that form natural gas, as the term is generally accepted, belong to the paraffin series. The quantities of the respective hydrocarbons present in the gas vary for numerous reasons. A simple method of expressing the general relationship is: the greater the gasoline content of the gas the greater the ratio of heavy to light constituents; and the drier the gas the greater the ratio of the light to heavy constituents.

The tabulation in Table 1 of several types of gases giving the molecular percentages of the constituents present and their equivalent values in gal. per M. cu. ft. of raw gas is more concise than lengthy discourse. Included in Table 1 are two analyses of raw natural gasoline as it is before being charged to the stabilizer for specification processing. An analysis of the rich oil from the absorber is also presented, giving both the molecular percent and liquid

(Continued on Page 82)

HOW TO DRILL DEEP A



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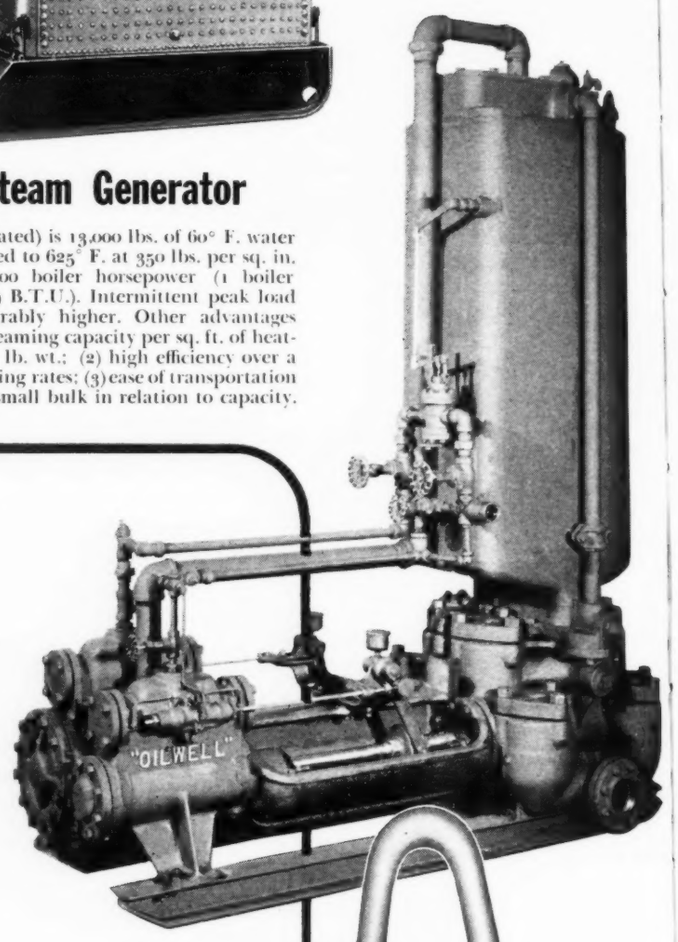
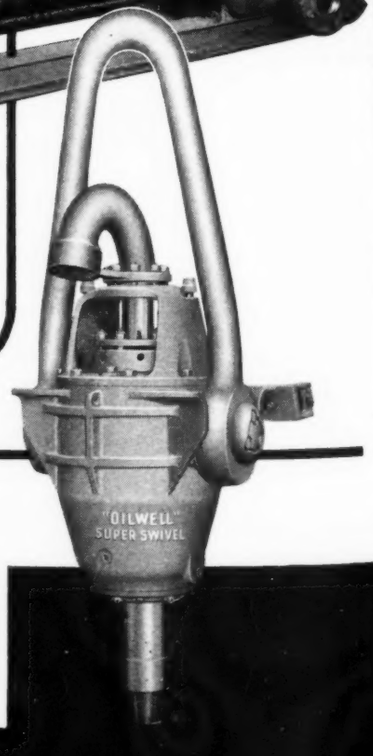
These improvements can easily be applied to "Oilwell" Feedwater Heater-Pump Units now in service. Write for details.





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100 r.p.m.	*17,000 feet*
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In drilling many of the world's deepest wells and establishing enviable records for drilling speed, "Oilwell" equipment has demonstrated its ability to overcome extreme conditions with a wide margin of safety. Of utmost importance also, is the consistent economy resulting from the low operating cost of "Oilwell" equipped rigs. The items shown here comprise only a small part of "Oilwell's" complete line. Requests for specifications are welcomed—there is no obligation. Write to any of the addresses shown below.

"OILWELL" 21-inch Super-Speed Rotary

Designed for and tested at 1000 r.p.m. table speeds and recommended for drilling to 17,000-ft. depths, the "Oilwell" Super-Speed Rotary offers several outstanding features, including: (1) positive forced-feed lubrication; (2) fully heat-treated, spiral-bevel gearing with the pinion given an additional surface hardening; (3) 2.61:1 gear ratio; (4) self-centering, angle-contact, high-speed main bearing with large-diameter, precision balls and through-hardened and ground, high-carbon, high-chrome steel races; (5) 300-ton supportable dead load capacity.

"Oilwell" No. 20 Steam Slush Pump

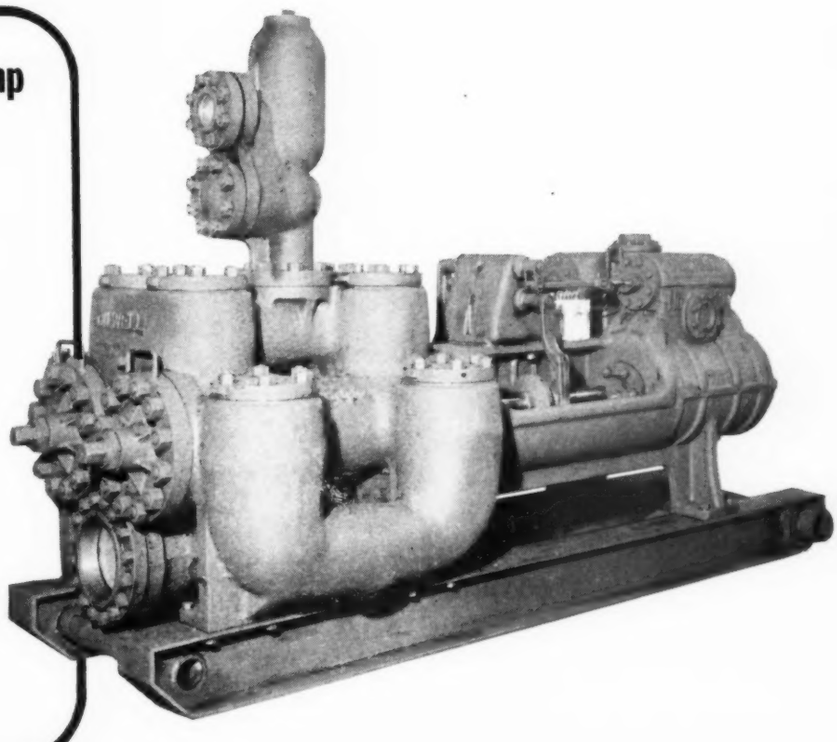
with New Heavy-Duty Parts

Constructed in accordance with time-proved design principles, the "Oilwell" No. 20 (16¼" x 7¼" x 20") Steam Slush Pump has repeatedly demonstrated its efficiency and dependability in drilling wells to extreme depths. The addition of new heavy-duty parts—fully interchangeable with older designs—now makes this pump even more efficient and dependable.

★*Roller-Bearing Valve Gear*—all bearing points are equipped with grease-lubricated, needle-type roller bearings. The lubricant is sealed in and foreign matter is prevented from entering. This improvement reduces wear, increases the life of valve-gear parts, and maintains maximum steam economy and full-stroke operation over a long period of time.

★*Type "HD" Roller-Bearing Liner Spacers*—adjusted externally by means of a single, large-diameter screw with a heavy-duty roller thrust bearing to facilitate free turning. The spacer body contacts the entire face of the liner collar, holding the liner securely in place against the highest working pressures.

★*Improved Type "C" Streamlined Valves and Seats*—both the valve and seat are heat-treated, one-piece, alloy-steel, drop forgings. Light weight and streamlined design extend wear-life and provide maximum fluid passage with minimum flow-restriction. Flexible, upper and lower valve-guide bushings greatly reduce wear on guides and stems.



OIL WELL SUPPLY COMPANY

(Continued from Page 79)

volume percent of the constituents present.

When the mol percent or gas volume percents are known for the constituents making-up a specific natural gas, the liquid volume or content in gal. per M. cu. ft. of the raw gas can easily be calculated. This calculation is made by taking the mol percent of each constituent as shown on the analysis sheet and multiplying it directly by the proper factor. The factors used by one of the large commercial laboratories are listed in Table 2.

If an analysis shows 18.6 mol percent of propane as in Sample No. 2, Table 1, the liquid propane content in gal. per M. cu. ft. of that particular gas would be $\frac{18.6 \times 27.3}{100} = 5.078$ gal. per M. cu. ft.

It is sometimes desired to know the liquid content represented by constituents other than those for which factors are given above. The factors found in Table 3 may be used in conjunction with those in Table 2 and satisfactory results obtained.

Constants

The constants of the hydrocarbons that occur in natural gas are to be found in numerous reference books. Some of the tables are complete for only a few of the constituents but others cover the entire range.

It is quite often desired to know the octane rating, or number, of the various hydrocarbons found in natural gasoline. Table 4, abstracted from an article by W. L. Nelson, lists several of these ratings.

The normal paraffin hydrocarbons are the most important of the petroleum compounds. Each differs from the next lower member in the series by CH_2 systematically. An examination of the tables concerning the physical properties of the paraffins will indicate that these tabulated properties are just as systematic in their differences.

A basic principle underlying gasoline extraction from natural gas absorption is that the lighter constituents can exist at normal temperatures and pressures only when they are in solution with heavier members of the series in the liquid phase.

Hydrocarbons in Natural Gas

Methane, the chief constituent of natural gas, CH_4, is colorless, odorless, and slightly soluble in water. It condenses at minus 259°F. and freezes at minus 298°F. It has a specific gravity of 0.554 as compared with air and a heating value of 1009 B.t.u. per cu. ft. of gas. Methane occurs very generally in nature, being formed by the decay of leaves, grass, etc. It is often termed "marsh gas." Methane is quite often present in coal mines and frequently is the direct cause of disastrous explosions. The miners call it "fire-damp."

Ethane, C_2H_6, is the next largest constituent in natural gas, from the standpoint of volume. It is slightly odorous, is colorless, has a condensation or boiling point of minus 127°F. and a freezing or melting point of minus 278°F. It is a gas at normal temperature and pressure, is more easily liquefied than methane, has a specific gravity of 1.038, and a heating value of 1795 B.t.u. per cu. ft. (in the gaseous form).

Propane, C_3H_8, the third member of the series, has a sweet ether-like odor, is colorless, and at ordinary pressure and temperature is a gas. It is the lightest constituent of natural gasoline, but is usually found only in the raw make as it is removed in subsequent operation for sale as a liquefied gas or for refrigeration purposes in the plant itself. Its presence in any appreciable amount in the finished gasoline will cause serious trouble because of high vapor pressure and low distillation recovery. Propane boils at minus 44°F. and freezes at minus 310°F., has a specific gravity of 1.523, and a heating value of 2580 B.t.u. per cu. ft. of gas. The A.P.I. gravity of the liquid is 146.

Butane, C_4H_{10}, normally is found as two distinct members of the series, each having the empirical formula, C_4H_{10}, and each having the same molecular weight, 58.08. Although each compound has the same number of carbon and hydrogen atoms in the molecule, the internal structure of the molecule is different. This difference in molecular structure in turn gives the two compounds different physical properties.

It is quite desirable to retain the butane in natural gasoline but many plants separate it in subsequent operation from the raw gasoline made by stabilization. The resulting product is then distributed as a liquefied gas or is used for plant refrigeration. The heavier constituents are shipped as a low vapor-pressure natural gasoline.

Normal butane has a boiling point of 30.9°F. and freezes at minus 211°F. In the gaseous form it has a specific gravity of 2.007 (air = 1); as a liquid it has a specific gravity of 0.583 (compared with water), and an A.P.I. gravity of 111. Its heating value as a gas is 3350 B.t.u. per cu. ft.

*Iso*butane has a boiling point of 10°F., it freezes at minus 229°F., has a molecular weight of 58.08, specific gravity as a gas of 2.007, and a heating value of 3266 B.t.u. per cu. ft. as a gas. As a liquid, *iso*butane has a specific gravity of 0.564 (compared with water) and an A.P.I. gravity of 120.

Pentane, C_5H_{12}, occurs as three compounds. Only two of these, however, occur in natural gas or natural gasoline —normal and *iso*pentane, respectively. Both pentanes are symbolized by the same chemical formula; molecular weight is 72.10; specific gravity as a gas is 2.491; several of the physical properties of the two fractions are equivalent, as noted in numerous references in the literature. Normal pentane, however, boils at 97°F., freezes at minus 204°F., has an A.P.I. gravity (as a liquid) of 93, a specific gravity

TABLE I

Table of Gas Properties

	Natural gas sample no. 1		Natural gas sample no. 2		Natural gas sample no. 3		Natural gas sample no. 4		Natural gas sample no. 5		Sample no. 6 (From raw gasoline make tank)	Sample no. 7 (From raw gasoline make tank)	Sample no. 8 (Rich oil from absorber)	
	Mol percent	Gal. per M. cu. ft.	Mol percent	Gal. per M. cu. ft.	Mol percent	Gal. per M. cu. ft.	Mol percent	Gal. per M. cu. ft.	Mol percent	Gal. per M. cu. ft.	Mol percent	Liquid volume percent at 60°F.	Mol percent	Liquid volume percent
Methane	84.48	.....	39.6	.....	94.96	.....	90.98	.....	57.33	.....	None	None	18.89	5.31
Ethane	7.75	.....	17.1	.....	2.81	.....	4.83	.....	11.45	.....	1.0	1.80	5.16	2.16
Propane	3.89	1.062	18.6	5.078	1.44	0.393	2.04	0.557	12.59	3.437	4.4	5.33	6.64	2.98
Isobutane	1.72	0.559	10.3	3.348	0.28	0.091	0.46	0.150	4.63	1.505	8.0	5.01	3.52	1.91
Butane (normal)	1.23	0.386	8.5	2.669	0.47	0.148	0.87	0.273	6.62	2.08	8.0	17.23	5.70	3.00
Isopentane	0.43	0.157	3.2	1.165	0.04	0.015	0.20	0.073	1.27	0.46	10.3	11.11	3.12	1.89
Pentane (normal)	0.28	0.101	1.7	0.615			0.36	0.130	2.54	0.92	8.3	18.48	4.32	2.59
Hexanes plus	0.22	0.090	1.0	0.410			0.26	0.107	3.57	1.54	60.0	41.04	52.65	80.16
Total liquid content		2.355		13.285		0.647		1.290		9.942				
Specific gravity		0.692				0.594		0.635						
Gross heating value, B.t.u. per cu. ft.		1222												

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LOW CARBON, ½ MOLY.	3 CR., 1 MOLY.
1½ SIL., ½ MOLY.	5 CR., ½ MOLY.
LOW CARBON, 1 MOLY.	5 CR., ½ MOLY., 1½ SIL.
1¼ CR., ½ MOLY.	5 CR., ½ MOLY., TITANIUM
1¾ CR., ¾ MOLY. (Bain Alloy)	5 CR., ½ MOLY., COLUMBIUM
2 CR., ½ MOLY.	8 CR., 1 MOLY.
2 CR., ½ MOLY., 1¼ SIL.	18-8
2½ CR., ½ MOLY., ¾ SIL.	18-8, TITANIUM
2¼ CR., 1 MOLY.	18-8, COLUMBIUM

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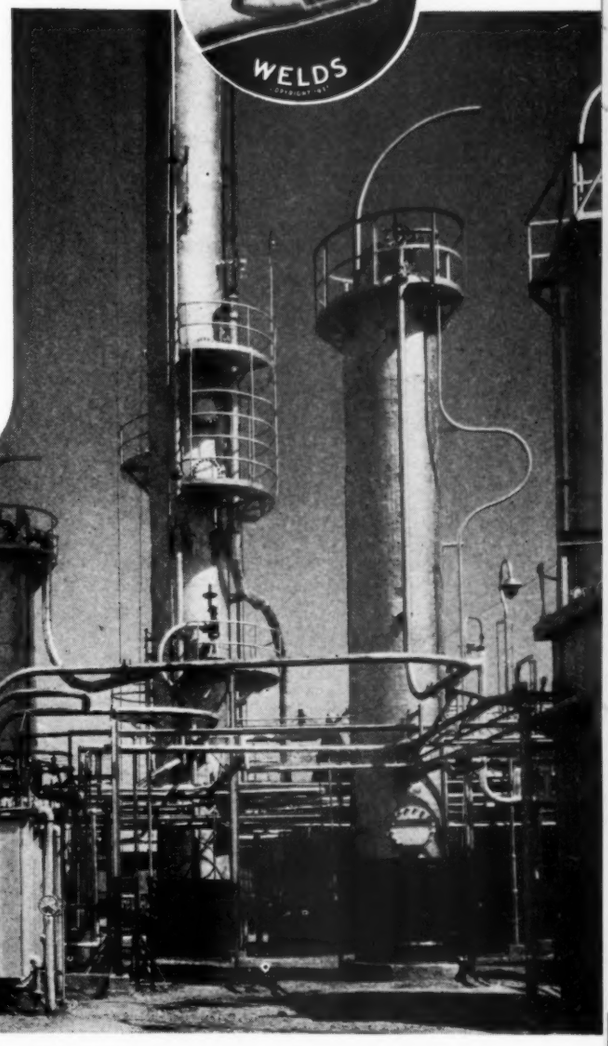

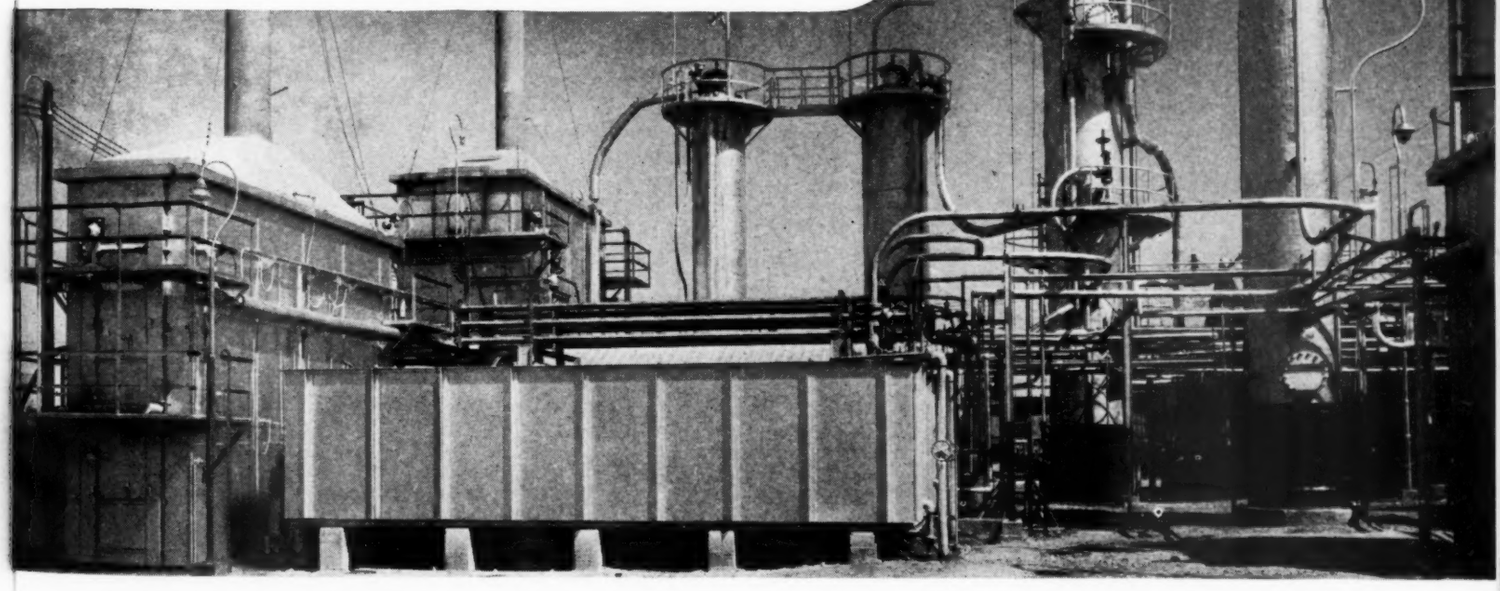

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UNITED STATES STEEL

TABLE 2

Constituents	Factor
Methane CH_4	....
Ethane C_2H_6	....
Propane C_3H_8	27.3
*Iso*butane C_4H_{10}	32.5
n-Butane C_4H_{10}	31.4
*Iso*pentane C_5H_{12}	36.4
n-Pentane C_5H_{12}	36.2
Hexanes plus C_6H_{14}+	41.0

of liquid (compared with water) of 0.631, and a heating value of 4007 B.t.u. per cu. ft. as a gas.

*Iso*pentane boils at 82.4°F., freezes at minus 256°F., has an A.P.I. gravity (as a liquid) of 95, a specific gravity of liquid of 0.625, and a heating value of 4012 B.t.u. per cu. ft. as a gas.

As the hydrocarbons increase in specific gravity and number of carbon atoms, the amounts present decrease rapidly after normal butane. The pentanes and heavier are the most desirable hydrocarbons as they constitute the greater volume in natural gasoline. For that reason it was accepted practice for a number of years to "lump" all the hydrocarbons above butane into the grouping, "pentanes plus," or "pentanes and heavier" on the gas analysis sheet. At the present time, however, laboratories are inclined to carry their analysis a little more into detail, separating the pentanes, showing them on the analysis sheet as individual constituents, and classifying only the hexanes and heavier as "hexanes plus."

Hexanes, C_6H_{14}, heptane, C_7H_{16}, and octane, C_8H_{18}, are to be found in most natural gases and gasolines to some extent. There are many gases in which the hydrocarbon, octane, is characterized by its absence. In gases when it is present, the proportion is usually quite small.

In the natural gasoline extraction process primary interest is in the extraction of all the pentanes and heavier, together with as much of the butane as the specified gravity, vapor pressure, and distillation recovery of the finished product will permit. Most modern plants also extract the remaining butanes not needed in the natural gasoline and the propane and market these fractions as liquefied gases conforming to accepted specifications. A few plants go further and extract a portion of the ethane.

Other Constituents

Natural gas contains certain other constituents that are not hydrocarbons. These constituents can well be termed impurities and consist of carbon dioxide, nitrogen, oxygen, water vapor, helium, hydrogen sulphide, and miscellaneous sulphur compounds.

TABLE 3

Constituent	Factor
Ethane	25.5
Hexane	41.0
Hexanes plus	43.0
n-Heptane	46.5
n-Octane	51.0

Carbon dioxide, CO_2, is found in all natural gases in some amount. The percentages range from just a trace to 30 percent, and in a few cases to 90 percent or more. The amount present is, however, usually less than 5 percent. Gases that are excessively high in CO_2 content are quite often processed to obtain solid CO_2, or "dry ice." Decomposition changes occurring during the formation of natural gas from organic remains of past geologic ages under widely varying conditions undoubtedly contribute to the varying percentages of carbon dioxide present.

TABLE 4

Hydrocarbon	Octane no.
Methane	125
Ethane	125
Propane	125
*Iso*butane	99
n-Butane	91
*Iso*pentane	90
n-Pentane	64
Hexane	....
Heptane	0
Octane	—0
Nonane	—28

Nitrogen is found in natural gas in varying quantities from a mere trace to as much as 98.5 percent. It is, however, seldom found in quantities large enough to prohibit the use of the natural gas as a fuel, its usual volume being less than 2 percent.

Oxygen is frequently found in natural gas. Its presence, however, is usually due to other than a natural cause. If present at all it is only as a mere trace.

Helium is present in natural gases from a mere trace to as much as 2 percent. Gases having high percentages of helium are being successfully processed and the helium extracted and liquefied for use in balloons and dirigibles.

Hydrogen sulphide is found in many gases in volumes seldom exceeding 2 percent. Hydrogen sulphide is poisonous and has a very foul odor. Natural gas often contains numerous sulphur compounds, the presence of which is objectionable in a finished natural gasoline. To remove these, it is necessary to treat the finished product so that the "doctor" and "corrosion" tests can be passed.

Sales of Bentonite Attain New High Mark

TOPPING by a wide margin the 1939 all-time record, sales of bentonite increased in 1940 to a new peak of 247,132 short tons, according to reports of producers to the U. S. Bureau of Mines. The 1939 output was 219,720 tons and the previous record was 194,768 tons in 1937. Although bentonite clay was used by pioneers in the western country to grease the wheels of their covered wagons and in place of soap, this mineral is a relatively new commercial product. As recently as 1925 the total output was less than 5,000 tons.

Bentonite is important to defense principally because of its use in foundry molding and core sands. Although small admixtures of this remarkable clay have come to be employed almost universally in sands for gray iron, malleable iron, and steel castings, it is rarely used in casting aluminum and is not essential in making airplane motor blocks and certain other castings. In other words, foundry consumption of bentonite tends to increase when the output of castings, especially iron and steel castings, increases, but not necessarily in direct proportion. In 1939, 53,872 tons, or not quite 25 percent of the total sales of domestic bentonite, was used in foundries and steel works; whereas in 1940, the quantity so used increased to 74,135 tons, comprising 30 percent of the total. By far the bulk of this bentonite is the swelling type produced in Wyoming and South Dakota. Increasing quantities of southern bentonite are used for foundry work, however. This type exhibits no extraordinary swelling properties when moistened but is even better than the Wyoming type for some kinds of casting.

Oil refineries are still the principal users of bentonite. This is all non-swelling clay, mostly Mississippi clay that is acid-treated or activated so as to convert it into an efficient bleaching agent. A moderate quantity of bentonite is also used raw as filter-aid and for other purposes in the oil refining industry, which accounted for 91,400 tons or 37 percent of the 1940 sales, compared with 95,247 tons or 43 percent of the total in 1939. The third largest use is in rotary well drilling mud for petroleum and natural-gas industries, which required 45,296 tons in 1940 as against 35,880 tons the preceding year, the percentage of the total increasing slightly to 18 compared with 16 percent in 1939.

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P 452.9
P 532.9

Reconditioning Oil Wells in The Greater Seminole Area of Oklahoma

PART 2

by J. I. Laudermilk Instructor, Petroleum Engineering, University of Texas

A photograph and biographical sketch of the writer can be found on page 114 of the May issue of *The Petroleum Engineer*, in connection with Part 1 of this article.

LOCAL subsurface conditions may be such that no inducement for reconditioning exists in certain areas. Due to localized geological features, it may be impossible for a given well to have any appreciable radius of drainage or for there to be any considerable amount of physical reserves of oil in the vicinity of the area drained by the well. Information concerning the probable size of the reservoir tapped by the well is very desirable, therefore, as is also knowledge of local subsurface conditions existing in the reservoir, which will affect the probable drainage radius of a given well.

Oil-Water Contact

The oil-water contact in the Upper Wilcox Sand in the immediate vicinity of the well in question is a factor of extreme importance. This knowledge allows the engineer to estimate the size of shot he can use without undue danger of increasing the rate of water encroachment.

The oil-water contact varies considerably in certain localities, due perhaps to local subsurface features that favor an increased rate of water influx. In the absence of more specific information, however, it has been established that a value of 3300 ft. sub-sea (below sea level with due corrections being made for vertical correction) may be accepted as fairly representative for the oil-water contact in the Upper Wilcox Sand in the Greater Seminole Area.

Total Thickness of Sand

Information on the total thickness of the Upper Wilcox Sand is very valuable as it is indicative of local geological structures. It is also desirable in order that the efficiency of production and recovery with partial penetration can be estimated.

All this information concerning the producing formation is very desirable but is seldom available in the case of oil wells drilled in the past. Modern technical developments in the study of reservoir data and its applications should in the future divulge definite knowledge of many other factors affecting the production of petroleum from a given formation in addition to those mentioned above. The factors enumerated above would be sufficient in the majority of cases, however, to permit an intelligent estimate of the proper procedure to follow insofar as the producing formation is concerned. Inasmuch as this information is very fragmentary in nature, the practical approach to the solution of the problems presented by the abovementioned group of factors affecting the producing formation is to take the available data and attempt to evaluate the unknowns in the light of past experience.

Production History

The production history has quite a distinct and important bearing on the possibilities and inducements for reconditioning work. If the decline in rate of production has been gradual, the present rate of production may be all that can reasonably be expected, in which case the shooting of the well would merely be a waste of money. If, however, abrupt declines have occurred in the production rate, the possibilities of the well in question should be thoroughly investigated. Even if no abrupt decline has been present, however, it is advisable in many cases to study the comparative production histories of several wells in a given region to determine whether the possibility of increasing the rate of production exists. Production records usually supply the criteria for selection of wells for reconditioning. It is extremely important, therefore, for a reconditioning engineer to have a knowledge of the production history, not only of his own wells but of all wells in the vicinity. Although extremely detailed data may be difficult or impossible to procure, general information can usually be obtained from field men who have worked in the area over a period of years, and who from personal recollections are conversant with events that may not have been recorded in the written records.

Prior Reconditioning History

Having obtained all available information, a thorough study of the prior reconditioning work (if any) that has been done on the well should be made as this will offer the best known means of estimating the results of prospective work. If prior shooting of the Upper Wilcox Sand in the well in question has resulted in an increase of production, it appears reasonable to conclude that similar results will be obtained elsewhere. Also, if favorable results have been obtained by shooting offset wells, this fact is indicative of a successful similar operation in a given well. Often the shooting of an oil well may be economically justified by subsequent decrease of production expenses, such as, for example, when sand is encountered in the well bore, causing subsurface equipment troubles. In these cases prior reconditioning history of various wells in the area will indicate the probable success or failure of such work. The extreme importance of detailed study of prior reconditioning work of all kinds cannot be overemphasized, as this work will serve as a basis for correcting the answers obtained by a purely academic approach to the solution of problems. The relationship between the academic and the practical results obtained from a given type of work may well be considered a "correction factor of experience."

In summarizing the factors affecting the shooting of the Upper Wilcox Sand in the Greater Seminole Area of Oklahoma, it should be borne in mind that many minor factors other than those mentioned above may be encountered occasionally in individual cases. The abovementioned factors are of primary importance, however, and a thorough understanding and an appreciation of the importance of each should permit an intelligent approach to the problems of reconditioning oil wells by shooting the Upper Wilcox Sand. It should especially be emphasized that each well must be considered individually on its own merits insofar as possible.

Results From Shooting

To an engineer engaged in reconditioning producing wells one of the most valuable aids is a capitulation of data showing the results obtained in the past by the same type of reconditioning methods used under similar conditions. Although many arguments have occurred in the past concerning the action of the explosion on the geological formation and various theories have been advanced to support the different viewpoints, the actual effects of such shooting upon production changes and the results obtained have been neglected to such an extent that the average reconditioning engineer has little other than personal experience or knowledge acquired by conversation upon which to base his estimate of the change in rate of production that will result from shooting. In this article no attempt will be made to advance a new theory of explosive action or formational reaction. Instead, a purely practical approach to the problem will be made, and field data will be presented showing results that have been obtained during a period of 11 years by shooting the Upper Wilcox Sand in the Greater Seminole Area of Oklahoma. These data have been purposely restricted to show only the change in rate of production that has been obtained during this period. No data are included herein to show the benefits obtained from shooting to improve operating conditions, such as reduction of sand trouble, gas trouble, etc., although such benefits frequently are sufficiently great in themselves to justify economically the reconditioning of oil wells by use of explosives.

TABLE 1

Individual well data
Shooting the Upper Wilcox Sand in the Greater Seminole Area of Oklahoma
1928-1939

Well	Date of shooting	Size of shot (quarts)	Concentration of shot (quarts per linear foot)	Wilcox Sand penetration, ft.	Distance of shot off bottom of well, ft.	Production string casing			
						Size, in. O.D.	Wt., lb. per ft.	Type	Remarks
1	January, 1928	10	1	12	0	7	24	Seamless steel	Not cemented
2	February	20	1	22	0	5½	17	Seamless steel	Cemented
3	April	20	2	13	3	7	24	Seamless steel	Cemented
4	April	30	1.5	20	0	7	24	Seamless steel	Not cemented
5	May	10	1	10	0	5½	17	Seamless steel	Not cemented
6	June	7	0.9	8	0	7	24	Seamless steel	Not cemented
7	November	40	2	20	0	7	24	Seamless steel	Not cemented
8	November	10	1	10	0	7	24	Seamless steel	Not cemented
9	December	20	1	23	2	7	24	Seamless steel	Not cemented
10	December	10	2	5	0	7	24	Seamless steel	Not cemented
11	January, 1929	10	1	10	0	7	24	Seamless steel	Not cemented
12	January	10	1	12	1	7	24	Seamless steel	Not cemented
13	January	20	1	21	0	7	24	Seamless steel	Cemented
14	January	20	1	24	4	7	26	Seamless steel	Not cemented
15	February	10	1	10	0	5½	17	Seamless steel	Not cemented
16	April	10	2.5	5	0	7	26	Seamless steel	Not cemented
17	April	10	1.4	12	2	7	24	Seamless steel	Not cemented
18	May	10	2	5	0	7	24	Seamless steel	Not cemented
19	May	10	1.4	7	0	7	24	Seamless steel	Cemented
20	June	10	2	5	0	7	24	Seamless steel	Cemented
21	June	10	3.3	3	0	7	24	Seamless steel	Cemented
22	July	10	1	12	1	7	26	Seamless steel	Not cemented
23	August	10	2	5	0	7	24	Seamless steel	Not cemented
24	August	20	2	12	0	7	24	Seamless steel	Not cemented
25	August	20	1	20	0	7	24	Seamless steel	Not cemented
26	September	20	2	10	0	7	24	Seamless steel	Not cemented
27	September	20	1	25	3	7	26	Seamless steel	Not cemented
28	September	10	0.8	12	0	7	24	Seamless steel	Not cemented
29	November	40	2	24	3	7	24	Seamless steel	Cemented
30	November	20	2.5	8	0	7	26	Seamless steel	Not cemented
31	January, 1930	20	2	10	0	7	24	Seamless steel	Not cemented
32	January	20	2	11	0	7	24	Seamless steel	Not cemented
33	January	20	2.5	8	0	7	26	Seamless steel	Not cemented
34	May	30	1.5	25	4	7	24	Seamless steel	Not cemented
35	July	50	2	25	0	7	24	Seamless steel	Cemented
36	December	20	2.5	8	0	7	24	Seamless steel	Cemented
37	January, 1931	20	2	10	0	7	24	Seamless steel	Cemented
38	January	40	2.5	25	5	7	24	Seamless steel	Cemented
39	April	40	3.3	16	3	7	26	Seamless steel	Not cemented
40	May	30	2	15	0	7	24	Seamless steel	Not cemented
41	March, 1932	30	1.5	25	0	7	24	Seamless steel	Cemented
42	May, 1933	30	2	15	3	7	24	Seamless steel	Not cemented
43	May	30	2	22	5	7	24	Seamless steel	Not cemented
44	October	30	3	10	0	7	24	Seamless steel	Not cemented
45	August, 1935	60	4	21	3	7	24	Seamless steel	Not cemented
46	August	60	3	22	1	7	24	Seamless steel	Not cemented
47	February, 1936	40	3.3	12	0	7	26	Seamless steel	Not cemented
48	May	50	4.2	12	0	7	24	Seamless steel	Not cemented
49	May	40	2	20	0	7	24	Seamless steel	Not cemented
50	May	120	4	30	0	7	24	Seamless steel	Cemented
51	June	60	3.3	20	0	7	24	Seamless steel	Not cemented
52	November	60	2.5	24	0	7	24	Seamless steel	Not cemented
53	November	20	2	10	0	7	24	Seamless steel	Not cemented
54	March, 1938	40	1	40	0	5½	17	Seamless steel	Cemented
55	May	30	3	10	0	7	24	Seamless steel	Not cemented

Two terms involving the change of production rate obtained by shooting will be used in this discussion. A clear understanding of the meaning of the terms, "initial change in production rate" and "sustained change in production rate," and the difference between them is essential to an understanding of this article and the data presented herein.

Initial Change in Production Rate

By "initial change in production rate" is meant the increase or decrease in rate of production obtained immediately subsequent to shooting as compared to the rate of production of the oil well just prior to reconditioning. That is: Initial change in production rate = [(production rate immediately subsequent to shooting) — (production rate immediately prior to shooting)] ÷ (production rate immediately prior to shooting).

Production tests conducted just preceding the reconditioning and upon completion of the work will reveal the initial change in production rate that has been obtained. These tests may be of only a few hours duration, or may extend over several days, but in either case should be reduced to the average production that can be obtained in a 24-hr. period. The significance of this factor lies in the availability and accuracy of the data obtained. These data are quite generally available and are usually the most accurate field data connected with production. It has long been customary to conduct tests of this type under exceptionally favorable conditions as regards supervision and mechanical equipment of the well. That is, when such tests are conducted, frequently producing equipment, especially subsurface equipment, has been replaced or repaired so that optimum instead of average operating conditions prevail.

Table 1 presents detailed individual well data concerning each of the projects involved. Table 2 gives the production data for each well during the test periods. These tables permit the presentation of the data in a more individualized manner than can be done graphically. It should be emphasized, however, that it is the general trend that is of interest rather than individual well peculiarities or results obtained in isolated cases. It should be recalled that the greater number of wells considered in this investigation have been producing from the Upper Wilcox Sand for a considerable number of years; the rate of production decline is not as appreciable, therefore, as it would be in wells not so far removed from flush production. Reference to the data presented in Table 2 will show that in many cases the de-

cline has been so gradual that the change in mechanical equipment and increased supervision will tend to make the actual decline obscure. This is evidenced by the fact that frequently production tests conducted just prior to reconditioning may indicate a somewhat higher rate of production than that obtained in routine operation over an appreciable period of time preceding these tests. It should, however, be borne in mind that both theoretically and practically the rate of production of these oil wells is declining to a greater or lesser degree depending on individual conditions affecting various wells.

Sustained Change in Production Rate

"Sustained change in production rate," on the other hand, means the increase or decrease of the *average* rate of production obtained by the shooting and sustained over an extended period subsequent to the shooting as compared to the average production rate of the oil well during an equal period of time prior to the work. It has been a commonly accepted rule-of-thumb that an ordinary reconditioning job in the Greater Seminole Area should pay for itself in increased oil production within six month's time subsequent to the work. This, of course, presupposes that the primary purpose of the reconditioning was to obtain an increased rate of production instead of being dictated by the desire to improve existing production conditions. In special cases this time element may be altered considerably, being either lengthened or shortened to meet the individual conditions. In general, however, reconditioning work that does not pay for itself in full within six months will seldom be economically justifiable. For this reason the term, "sustained," has been used to mean sustained over a period of six months. That is: "Sustained change in production rate" = [(average production rate for six months subsequent to shooting) — (average production rate for six months prior to shooting)] ÷ (average production rate for six months prior to shooting).

To determine the sustained change in production rate, therefore, it is necessary to have available the record of one year's production of the well. Comparison of the average rate of production for the period subsequent to the shooting with the average rate of production for the equal period prior to the reconditioning work will reveal the sustained change in production rate obtained. Where proration is in effect this factor must be eliminated in order to avoid a false or distorted picture. This can best be done by the use of periodic tests of the well's total producing capacity instead of use of the well's allowable production.

It is evident that the sustained change in rate of production is of considerably more importance than the initial change in production rate. It may be entirely possible to obtain favorable changes in rate of production by shooting an oil well and yet have this increase vanish in such a short period of time that no economic justification for the work exists, and an economic loss will have been incurred despite the favorable trend immediately apparent. In the past there have been no data available on this important subject. The general practice has been to estimate the change in production rate that would immediately result from the shooting of an oil well and hope that some part of this increase would be sustained over a sufficiently long period of time to pay for the cost of the work and return a profit, or initially to estimate the immediate results so conservatively as to allow for some decline.

The individual shooting jobs considered in this article were undertaken during the 11 years from January 1, 1928, to January 1, 1939, and present a comprehensive study of the field results of shooting the Upper Wilcox Sand in this region for the purpose of obtaining favorable changes in rates of production. Jobs undertaken for other reasons not related to increasing production (i.e., removal of debris from well bore, elimination of sand trouble, etc.) were not considered in this investigation, as their different characteristics warrant individual study on their own merits.

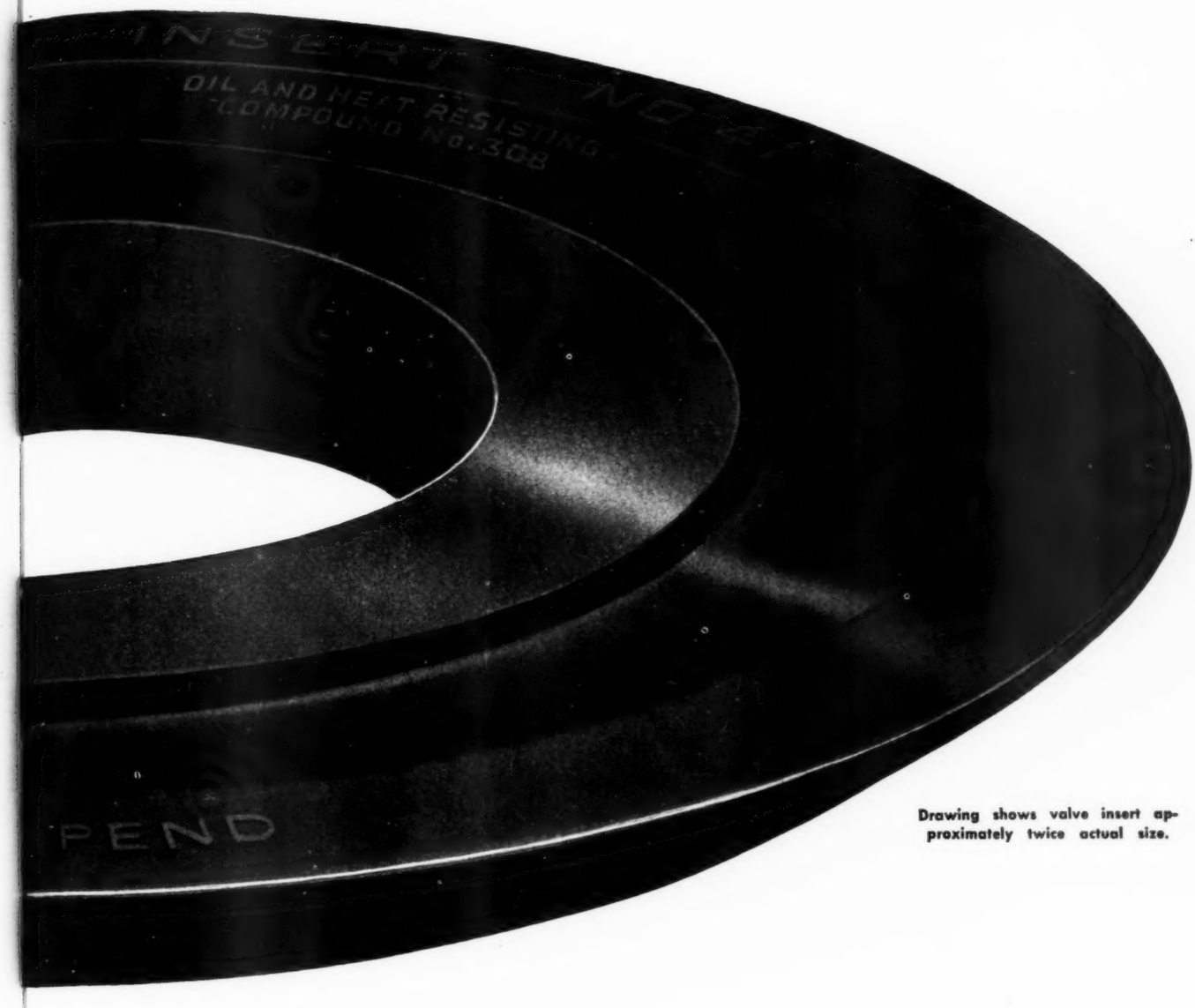
EDITOR'S NOTE: This article will be concluded in an early issue of *The Petroleum Engineer*.

TABLE 2

The effect of shooting the Upper Wilcox Sand in the Greater Seminole Area of Oklahoma 1928-1939

Well no.	Initial change in production rate					Sustained change in production rate				
	Production tests				Increase in production rate of oil, percent	Production tests (six months averages)				Increase in production rate of oil, percent
	Before shooting		After shooting			Before shooting		After shooting		
	Oil	Water	Oil	Water		Oil	Water	Oil	Water	
1	280	0	408	0	46	295	0	394	0	34
2	185	0	995	0	438	197	0	402	0	104
3	12	65	20	90	67	10	60	17	75	70
4	8	0	18	2	125	9	0	16	3	78
5	35	0	95	0	171	33	0	84	0	155
6	440	20	608	30	38	418	20	538	35	29
7	96	5	114	5	19	90	5	109	7	21
8	15	30	90	130	500	16	30	84	115	425
9	70	0	133	0	90	81	0	127	0	57
10	10	15	15	15	50	10	15	16	15	60
11	290	10	300	10	3	275	10	288	11	5
12	210	5	550	10	162	198	5	401	10	102
13	110	3	142	5	29	114	5	136	5	19
14	75	0	220	0	193	93	0	211	0	127
15	42	5	100	10	138	40	5	88	10	120
16	40	0	50	0	25	39	0	49	0	26
17	230	0	388	15	69	249	0	374	0	50
18	130	0	527	0	305	178	0	432	0	142
19	180	10	250	110	39	173	10	228	100	32
20	200	0	470	30	135	218	0	434	35	99
21	125	25	240	40	92	120	20	232	40	93
22	55	0	68	0	24	53	0	65	0	23
23	100	50	165	40	65	110	50	179	60	63
24	150	0	218	0	45	142	0	196	0	38
25	70	0	50	0	—29	80	0	63	0	—21
26	160	0	180	10	12	156	0	172	15	10
27	100	0	100	0	0	98	0	107	0	9
28	20	0	80	0	300	22	0	77	0	250
29	90	5	155	10	72	94	5	141	10	50
30	180	100	90	160	—50	192	100	83	170	—57
31	51	0	79	0	55	50	0	73	0	46
32	40	0	140	0	250	62	0	131	0	111
33	142	0	226	0	59	140	0	214	0	53
34	141	0	78	0	—45	161	0	93	0	—42
35	272	0	485	0	78	291	0	448	0	54
36	61	0	80	0	31	60	0	77	0	28
37	350	0	347	0	—1	371	0	316	0	*
38	105	10	125	13	19	102	10	118	15	16
39	180	0	243	0	35	185	0	240	0	30
40	150	5	185	8	23	170	5	199	10	17
41	195	20	230	20	18	187	20	217	25	16
42	200	0	282	0	41	191	0	260	0	36
43	10	0	60	120	500	10	0	50	135	400
44	160	0	252	0	58	141	0	206	0	46
45	94	0	250	0	166	91	0	145	0	59
46	38	10	192	45	405	35	10	180	52	414
47	12	10	35	28	192	11	9	33	25	200
48	160	0	110	62	—31	197	0	101	59	—49
49	96	20	172	35	79	140	20	145	32	4
50	61	0	42	0	—31	98	0	55	0	—44
51	54	0	160	0	196	126	0	154	0	22
52	88	0	164	10	86	73	0	112	0	53
53	90	17	80	17	—11	90	28	83	17	—8
54	20	40	104	81	420	18	37	69	71	284
55	59	257	108	245	83	51	287	96	296	88

*Normal decline of well.



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What Is a Safety Factor?

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by W. L. Ducker, Jr.
Product Engineering Company

THERE is probably no single technical term in the entire field of engineering that enjoys a more universal use, or a more liberal interpretation, among engineers and laymen alike, than does the term "safety factor." Because its true and accepted meaning as employed by designers is at such variance with the common understanding of the term, it should be of prime importance to every person whose regular or occasional responsibility is to specify or operate mechanical equipment, to understand precisely what the term "safety factor" does mean, and thus avoid the hazard of *relying on the safety it so wrongly implies.*

The popular conception of the term safety factor, as it is applied to mechanical equipment, is that it represents some definite reserve capacity or strength beyond the rated capacity or strength of the machine, separating that rated capacity from a known point where failure will occur, by a great enough margin so that no reasonable load or overload will ever quite reach that point and produce failure.

W. J. M. Rankine, well known for his early works in the fields of thermodynamics and applied machines, has referred to this quantity as the "factor of ignorance." But to hold with, and to set about to defend such a definition despite the fact that on certain classes of mechanical design a factor of as much as four or five to one is used, would seem to charge that designers cannot rely on the results of their design and analytical methods to any closer limits than those indicated by the amount of the safety factor. It would further seem to indicate that the science of applied mechanics is anything but the exact science that it is purported to be.

Ambiguous as the foregoing statements seem to be, it is none the less a demonstrable fact that with analytical methods that will yield results reliable to within maximum limits of as little as 25 percent, it is not impossible nor even uncommon to obtain an overall "factor of ignorance" as high as four or five to one.

W. L. DUCKER, JR.

was district engineer at Seminole, Oklahoma, for Barnsdall Oil Company, 1928-29—Design engineer for Petroleum Chemical Corporation, 1930-31—Plant engineer for Consolidated Gas Utilities, 1932—Chief engineer in charge of mechanical design of instruments and heavy equipment for Seismograph Service Corporation and Engineering Laboratories, Inc., 1933-38—Chief engineer, Bovaird Supply Company, 1938-40—Is now senior member of Product Engineering Company, consulting engineers, Tulsa, Oklahoma—Received B.S. degree in mechanical engineering from University of Oklahoma.

Apparent Safety Factor

In 1906, F. E. Cardullo, in an effort toward refinement of design and economy of materials in machine construction, first suggested the composite nature of the safety factor. In an article appearing in *Machinery* in January of that year, Cardullo defined the "apparent safety factor" as being the product of four primary factors covering:

(a) The characteristics of the material used.

(b) The nature of the stresses setup in the material.

(c) The nature of the loads imposed.

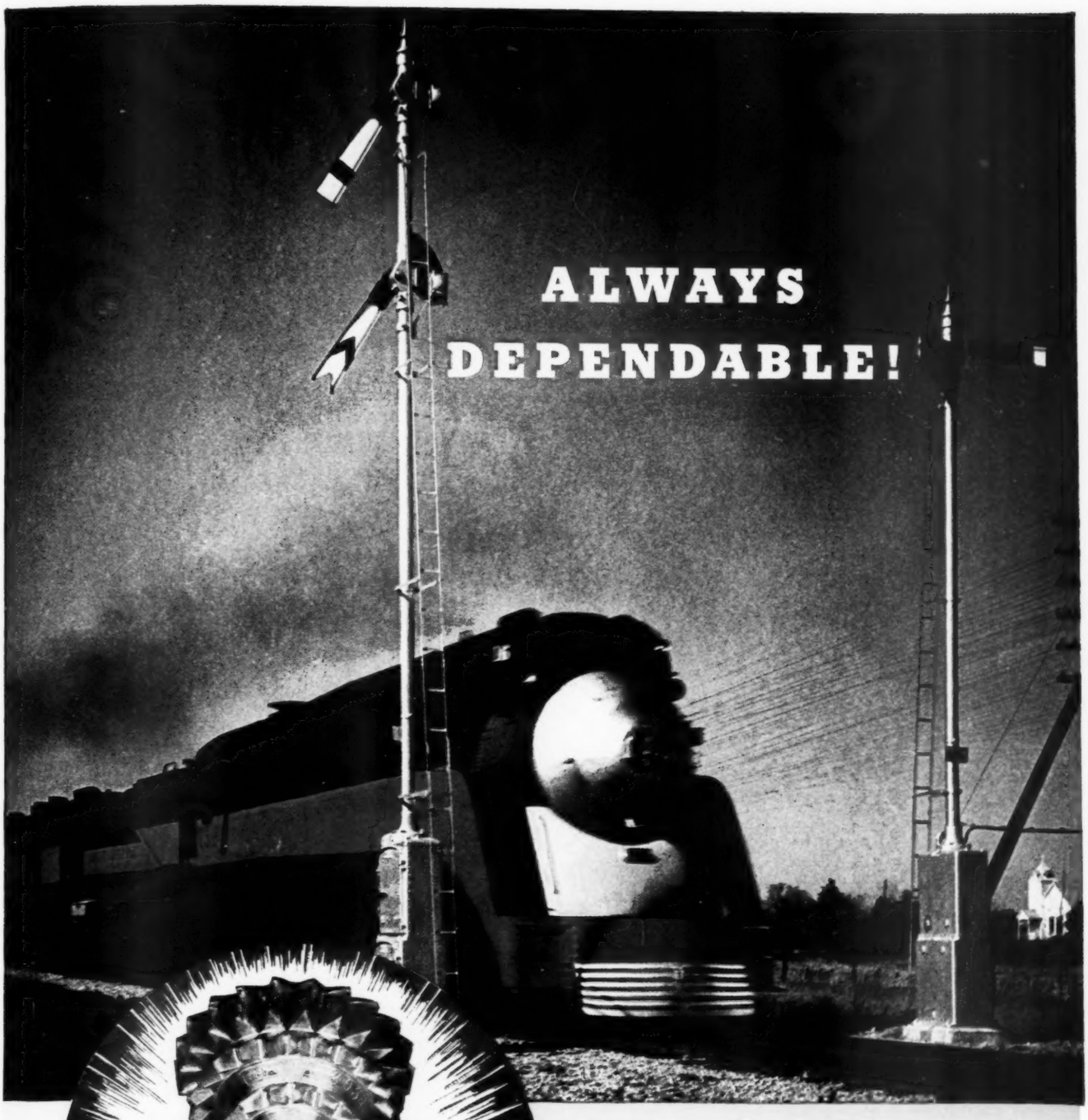
(d) Any other unknowns that might possibly be present.

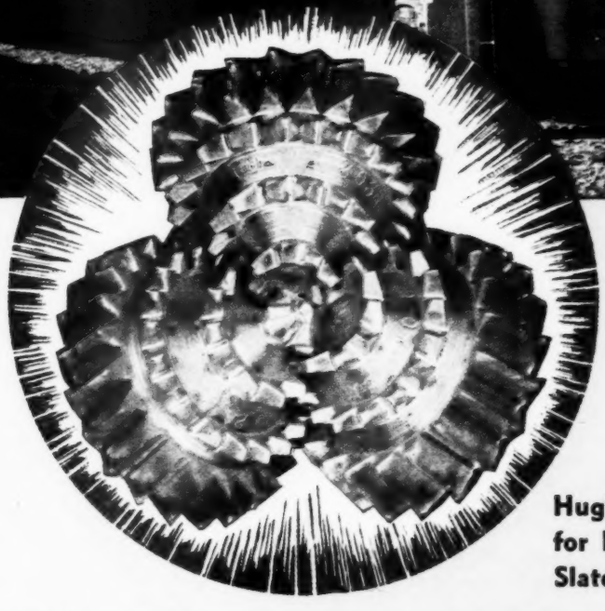
Tables were supplied, giving recommended values of these primary factors for various classes of machine design and service. These combined to produce apparent factors of safety ranging, for example, from 4 on structural steel buildings to 24 for mill shafting.

This conception of the composite nature of the safety factor was an important forward step in the advancement of machine design. It made possible an intelligent appraisal of the components involved, with the result that on those portions of the design for which particularly reliable analytical methods were available, the primary factors could be reduced to values closely approximating the degree of reliability of that particular analysis. Consequently, the overall, or apparent safety factor could be reduced, with the accompanying reduction in the material and weight of the finished machine or member.

Refinements

Since that day, research in the field of applied mechanics, spurred by the constant demand for ever lighter and stronger construction, has developed refined methods of analysis. These have made it possible, in many instances, for the designer to weigh the reliability of the design or analytical methods employed, and to ascribe extremely close values to the primary factors. As a result the old, crude, and uneconomical method of assuming one lump safety factor to cover the whole of a particular design is rapidly giving way to the more refined and precise practice of considering each part of the design individually and assigning to that part a primary factor that is a close approximation of the "reliability constant"





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of those particular methods made use of in the analysis of the piece. In the aircraft industry, where minimum weight on the one hand, and reliability and safety on the other, are of the utmost importance, it is the universal practice to calculate the stresses due to loading, the stress concentrations, fabrication stresses, and all other phases of the problem individually, to consider carefully the reliability of the analytical methods used, and then to apply to each calculation a primary factor judged to just cover the possible discrepancy between the calculated values and the actual values that might exist. In such cases the overall or gross safety factor does not even exist, except as one might choose to combine all the primary factors used and to call the result the overall safety factor. Dr. V. L. Maleev,[1] in his recently published treatise on machine design,[2] defines the factor of safety as "the ratio of limit stress to the design stress." He defined the limit stress as "the maximum stress to which a machine part can be subjected without damage," and the design stress as "the maximum stress that should not under any circumstances be exceeded in a properly designed machine," to which the author adds "*to allow for the inaccuracies in computation, workmanship and quality of material,* the design stress . . . must always be lower than the limit stress. . ." This is to say that the safety factor is the result of individual allowances for those factors that are beyond the ability of design to evaluate to any closer limits.

It has been shown how advancement in the knowledge of applied mechanics has made possible the individual consideration of the various components of the design problem, and has in many cases made possible the application of extremely close values to the primary safety factors, thus tending toward more exact solutions of the design problem and to the use of much smaller overall safety factors. This same advancement, however, has brought to light many new and heretofore unrecognized phases of machine design that must now be recognized and given the same consideration as those previously known; to these must be applied the necessary primary safety factors. It develops, therefore, that although the minimum safe values of the primary factors have decreased with advancement of the science, the number of the necessary primary factors has increased. The net result in some cases has been that the overall factors have not been reduced materially, and yet in all cases the ratios of limit stresses to design stresses will be uniformly much more consistent with actual working conditions of the machine parts than has been possible heretofore.

[1]Professor of mechanical engineering, Oklahoma A. and M. College.

[2]*Machine Design*, published by International Textbook Company, Scranton, Pennsylvania.

An Example

The following example will serve to illustrate the manner in which a design involving extremely close primary factors in the individual phases of the problem can, through the number of such factors, acquire a relatively large overall safety factor. For the purpose of illustration, the design of a steel casting will be assumed. It is found upon analysis of this problem that all the following points are of sufficient importance to demand individual consideration. After they have been given the most careful analysis possible, the following allowances are made for the possible limitations of the analytical methods employed in the evaluation of their effect on the strength of the part:

	Allowance percent	*Primary factor*
(a) Dimensional variations in the casting	3	1.03
(b) Variations in alloying elements, etc., of the material	15	1.15
(c) Quality of the casting	6.5	1.065
(d) Workmanship in machining	10	1.10
(e) Magnitude of applied load	25	1.25
(f) Effect of rate of loading	20	1.20
(g) Effect of stress reversals	25	1.25
(h) Effect of vibration	15	1.15
(i) Magnitude of stress concentrations due to discontinuities of form	25	1.25
(j) Magnitude of internal stresses due to heat treatment	20	1.20

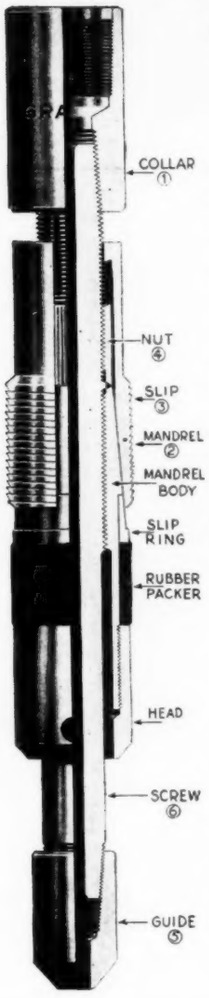
It is assumed that the best practice in design has been followed and that the above primary safety factors have been assumed to cover the *possible discrepancies between calculated values and actual working conditions.* For the individual items, the above values are probably closer than would generally be possible in practice. Close as these individual factors are, however, they are all of such a nature as to be cumulative in their effect on the strength of the finished piece. And if an overall factor is to be calculated, it must be the *product* of the individual primary factors. This will be found to be 4.50. The reader's first thought may be that this figure seems high for a factor of ignorance, yet if all the primary factors making up this resultant figure were by chance totally justified, such an overall factor would be necessary. It is the lack of perfection of analysis that makes it difficult to say definitely whether the assumptions are exaggerated or not.

It has thus far been shown that a safety factor as employed in modern design is in fact a "factor of ignorance" employed to cover that interval between the load requirements of the machine member and the strength it would possess if all the calculations of design and all the phases of manufacture and material were perfect, and if the allowances for imperfections were unjustified. But it cannot be known to what extent those allowances or primary factors are justified, as they are based only on the best judgment of the persons making the design. It, therefore, follows that the actual strength of the machine or member would be just equal to its rated or nominal capacity or strength, if all the primary factors employed were totally justified; or the actual strength would be equal to the nominal or rated strength times the gross or overall safety factor, if none of the primary factors employed were in any measure justified. It can, therefore, be seen that the safety factor *does not* "represent some definite reserve capacity or strength beyond the rated capacity or strength of the machine, separating that rated capacity from a known point where failure will occur, by a great enough margin that no reasonable load nor overload will ever quite reach that point and produce failure." Instead it represents an interval between the rated capacity or strength of the machine or member, and a known point where failure would certainly occur. It is *somewhere within that interval* that the actual strength of the machine will be found, and at that point within that interval failure will occur.

The danger in the practice of specifying mechanical equipment for operation under loads that in any degree exceed the rated capacity should now be apparent, for as soon as the rated capacity of a properly designed machine is exceeded, it is operating within the region in which point of failure is known to exist. Yet such overload specification is frequently practiced under the argument that "the machine will certainly stand up under a 25 percent overload, as it has a *safety factor of 3 to 1,* which is surely large enough to cover it safely."

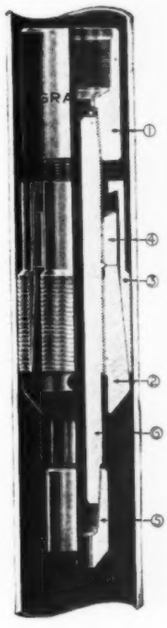
It sometimes happens, however, that experience in the operation of a certain piece of equipment will show that the safety factors employed in the design were not wholly justified. In other words, *experience* shows that the unit will sustain certain overloads without failure. In such cases the manufacturer may sanction the practice, when necessary, of specifying the equipment for use in applications slightly beyond its rated capacity. This practice, however, relies on the results of successful past operating experience, rather than on any safety factors involved, because safety factors themselves guarantee no safety beyond rated capacities.

GRAY Rotary Fishing Tools



ON THE JOB *are good insurance against* LOSS OF TIME

With the tools on hand—on the rig—there will be no dangerous delay in getting the fish out of the hole. Gray's principal fishing tools—spears and overshots—answer about 95% of all fishing problems. The operation of these tools is simple and effective. A special operator is not required in order to assure proper functioning of the tools, due to their simplicity.



GRAY RELEASE SPEARS INSURE POSITIVE HOLD ON THE FISH AND 100% RELEASABILITY

The Gray Release Spear, in general use in oil fields throughout the world, has a simple releasing mechanism composed of two screw jacks. Either of these jacks will release the spear, and by operating together they assure positive hold on the fish and 100% releasability. Gray Spears, like all other Gray Fishing Tools, are built of adequate strength to perform the job for which they are intended. They are low in cost—a sound investment for any operator as good insurance against loss of time if trouble develops.

THE GRAY OVERSHOT IS THE SAFEST TOOL THAT CAN BE RUN IN AN OIL WELL

The Gray Releasing Overshot is as nearly universal as a fishing tool can be. It represents a refinement found in few tools of this class in that improvements have made it stronger and its operation simpler.

GRAY TOOL COMPANY
HOUSTON

For complete description of these and other Gray Fishing Tools, see the 1941 Composite Catalog, or literature will be sent upon request

Running Tour

WITH MEN IN THE INDUSTRY

R. L. VERNOR assumed his new position as general manager of Smith's Bluff, Texas, refinery of the Pure Oil Company June 1. He has served as superintendent of the refinery for the last 18 years. Vernor's assistant for several years, JACK S. ALLEN, is now superintendent. Assistant superintendent of the plant is I. L. HOSTETLER, formerly assistant manager of the Pure Oil refinery at Newark, Ohio.

L. J. LYNCH has been appointed Detroit, Michigan, representative for the Morris Machine Works, Baldwinsville, New York, manufacturers of centrifugal pumps, hydraulic dredges, and steam engines. Lynch has his office at 403 Kales Building, Detroit.

CHESTER M. GARDINER, petroleum geologist and valuation engineer, has moved his offices from 707 Hill Street to Suite 1024, Security Title Insurance Building, 530 West Sixth Street, Los Angeles, California.

JACK H. MCLELLAN is now in the design engineering department of the Solvay Process Company, Hopewell, Virginia. Before joining Solvay, McLellan spent six months traveling in Eastern states on work for the Federal Government. Formerly he was with Phillips Petroleum Company, Bartlesville, Oklahoma.

JESSE J. RICKS, formerly president of the Union Carbide and Carbon Corporation, New York, New York, has been elected chairman of the board. BENJAMIN O'SHEA, formerly vice-president, is now president. JAMES A. RAFFERTY, a vice-president, was elected to the board of directors to fill the vacancy caused by the resignation of MATTHEW J. CARNEY. ROBERT W. WHITE, secretary and treasurer, was also elected a vice-president.

WILLIAM A. MARSTELLER has been appointed advertising and sales promotion manager by The Edward Valve and Manufacturing Company, Inc., East Chicago, Indiana. Marsteller has had nine years' newspaper, advertising, and sales experience in Champaign, Illinois, and Chicago.

GEORGE T. KILMON, member of The B. F. Goodrich Company legal staff for the last 16 years, has been elected assistant secretary by the board of directors. He will fill the vacancy caused by the death of J. L. MCKNIGHT. EDWARD M. MARTIN was elected assistant treasurer.

TOM MURPHY, Martin-Decker Corporation salesman, is now covering the Canadian oil fields for his company. Murphy left Long Beach, California, recently for Canada and expects to be gone several weeks.

DAVID APPLEBAUM has resigned as material and commissary superintendent of Tropical Oil Company, Colombia, South America, because of ill health. Applebaum has had 20 years' service with Tropical and is now establishing his residence in Houston, Texas.

MYRON L. GILBERT, former office manager for Sunray Oil Company, Allen, Oklahoma, is now a general superintendent with Petroleum Refining Corporation, Shelby, Montana.

T. H. GIBBS, who was district engineer for Standard Oil Company of Louisiana at Rodessa, is now in the wire rope division of the Bethlehem Steel Corporation, Williamsport, Pennsylvania.

S. F. SHAW, consulting engineer of San Antonio, Texas, recently returned from a five weeks' trip to the Turner Valley field, Canada, and is now inspecting properties in the Bancroft field, Louisiana, and Silsbee field, Texas.

H. W. FIELDS has been appointed manager of a new Frick-Reid Supply Corporation store at Oil City, Mississippi. Fields is being transferred from Rodessa, Louisiana. GEORGE C. PRYOR will succeed Fields as store manager at Rodessa.

M. L. (LYLE) CASHION, assistant production superintendent of Gulf Oil Corporation of Houston, Texas, is chairman of the group of oil company representatives to confer with Louisiana minerals department officials on proposed regulations to govern oil fields not covered by special orders.

JAMES H. MAGUIRE recently retired from active duties as works manager of Haynes Stellite Company, Kokomo, Indiana. He will continue with the company in a consulting capacity. Other personnel changes in the works organization of the company are as follows: F. T. MCCURDY, general superintendent; J. R. BROWN, assistant superintendent; and H. C. FRETZ, as assistant to the superintendent, will be in charge of foundries.

WILLIAM F. KRUEGER, representative of the Sperry-Sun Well Surveying Company, has been called for active duty by the U. S. Army. Krueger is a first lieutenant and will be located at Camp Livingston, Louisiana.

G. R. KING was elected president of The Petroleum Engineering Club at Texas A. and M. College, College Station, Texas. LOUIE TOMASO was elected vice-president; GENE CAPERTON, secretary, and BILL DORAN, treasurer. The new officers of the club will serve during the school year 1941-'42. E. O. BUCK of Houston, Texas, spoke on "Recycling Gas for Condensate Recovery" at the election meeting.

HAROLD R. MEYER, who has been a trainee in the refinery division of The Texas Company and stationed at San Antonio, Texas, has been made chief chemist of the Craig, Colorado, refinery.

HERBERT WILLIAM PINCHBECK, driller, has been transferred from Sarawak Oilfields, Ltd., Miri, Sarawak, to The Anglo-Egyptian Oilfields Company, Ltd., Hurghada, Egypt.

J. E. BOGK was recently transferred to Kansas City, Kansas, as refinery superintendent for Phillips Petroleum Company. Bogk has been chief process engineer at Bartlesville, Oklahoma. He succeeds JEFF MITCHELL, who is now in Bartlesville as manager of the refining department's main office. E. H. BENDER has also been transferred from Bartlesville to Borger, Texas, succeeding HUGH MILLER, refinery superintendent, who has been promoted to general superintendent of all refinery operations.

HERMAN F. DAVIES has been named vice-president in charge of operations of the California Company, and is transferring from Denver, Colorado, to newly established headquarters in New Orleans, Louisiana. RALPH D. COPLEY, formerly assistant manager of the producing department, will remain in Denver to take charge of the company's Rocky Mountain operations.

We strongly recommend *this* welded pipe for Gathering and Service Lines

"Spang" shows the way to another means of cutting corners on costs around the well—without sacrifice in safety. Your lines for water, steam, gas, oil, mud and other services, demand a fully dependable, easy-working pipe . . . and Spang CW Pipe will do *all* these jobs at a saving.

Why? Because uniformly strong welds make Spang CW *safe* from end to end . . . uniform quality makes cutting, threading and bending always fast and trouble-free . . . uniform lengths are easily handled . . . cleaner inside surface eliminates the cause of clogged meters, valves or traps. Accurate mill threads make-up fast . . . assure tight joints. These are the "differences" you've needed in pipe for gathering and service lines ...now they are *all* available in Spang CW Pipe. When you order, be sure to specify *Spang CW Pipe* by name.

Uniform

IN QUALITY
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WELD STRENGTH
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WALL THICKNESS
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ROUNDNESS
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DIAMETER
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IF IT'S
CW
IT'S SPANG

J. Alberts Hayes of Boston, Massachusetts, is now president of the National Association of Purchasing Agents for 1942. The 1942 convention will be held in New York City, New York. Ben R. Newberry, purchaser for the Lone Star Gas Company, Dallas, Texas, is vice-president for Region No. 2, which includes the purchasing agents of Tulsa and Oklahoma City in Oklahoma, and Dallas, Fort Worth, and Houston in Texas. Re-elected head of the editors' group of the national association was H. M. Cosgrove of the Tulsa association.

Donn Crall, who is superintendent for the Stanolind Oil and Gas Company, was elected president of the Seminole Chapter of the American Petroleum Institute at the annual meeting of the chapter. Crall succeeds Coxey Evans of Seminole, Cities Service Oil Company superintendent. Al West, Carter Oil Company district engineer, and Sammy Trent, district engineer for the Atlantic Refining Company, were elected first and second vice-presidents, respectively. W. R. Warren, Stanolind employee at Wewoka, Oklahoma, was appointed secretary-treasurer. The main speaker at the annual meeting of the chapter was Harry W. Ross of the Tulsa, Oklahoma, office of Dowell Incorporated, who talked on "New Techniques of Acidizing."

John L. Ferguson, Amerada Petroleum Corporation, succeeds Joseph L. Borden, Pure Oil Company, as president of the Tulsa, Oklahoma, Geological Society. Other officers elected are: Louis Lukert, The Texas Company, first vice-president; Howard Conhaim, consulting geologist, second vice-president; M. R. Spahr, Carter Oil Company, secretary-treasurer; and Charles Ryniker, Gulf Oil Corporation, editor. New council members of the society include Louis Roark, Margay Oil and Gas Company; John W. Merritt, Geochemical Service Company, and William E. Horkey, Superior Oil Corporation.

W. J. Larsen, Union Oil Company's superintendent in the Los Angeles Basin, has been placed in charge of production of crude oil, natural gasoline, and natural gas in that district. He will maintain offices in Santa Fe Springs, California.

Arthur C. Logan of Wilmington, Delaware, succeeds A. Faisch, Dixon, New York, as director of the Panhandle Eastern Pipe Line Company. Logan is an attorney for the Missouri-Kansas Pipe Line Company, holder of much of the Panhandle Eastern stock.

John W. Sutton, Shell Oil Company, Inc., production department, has been transferred from the Houma district, Louisiana, to the Iowa district as district superintendent.

J. R. Vandever and J. F. Adkisson, division superintendent and division engineer, respectively, for the Sunray Oil Company production offices in Wichita Falls, Texas, have been transferred with their entire personnel to Fort Worth, Texas, with their new quarters on the eighteenth floor of the Fair Building.

R. A. Cattell, head of the petroleum division of the U. S. Bureau of Mines, Washington, D. C., recently conducted a conference with Bureau officials at Bartlesville, Oklahoma.

Jack Barclow, geologist and engineer, has been transferred from Oklahoma City, Oklahoma, to be office manager of the Tulsa office of Lane-Wells Company.

Stanley H. Cathcart, former senior geologist of the Pennsylvania topographic and geological survey, has been reappointed a member of the survey.

Dr. Frank S. Hudson has accepted a position as efficiency engineer of Yuba Consolidated Gold Fields. Dr. Hudson recently resigned as chief geologist of Shell Oil Company, Inc., with offices in Los Angeles and San Francisco, California.

P. B. Watson, vice-president and general manager of W. R. Davis, Inc., Houston, Texas, is now president of the newly acquired Valley Pipe Line Company. Vice-president is Austin B. Taylor; secretary, M. V. Hansell, and treasurer, John H. Burns.

A. C. Mattei, president of Honolulu Oil Company, is spending his vacation in Honolulu this year, but is expected to return soon to his offices in San Francisco, California.

I. J. Rees, electrical superintendent for E. H. Moore, Inc., has left the company to accept a position with the Federal Power Commission at Washington, D. C. Joe T. McKinley, former assistant to Rees, has been promoted to fill the vacancy.

Gordon W. Reed, president of Texas Gulf Production Company, has been called to Washington, D. C., to take charge as director of priorities for aluminum and magnesium, one of the most important posts in the armament program.

Dr. C. F. Rassweiler has been appointed director of research for Johns-Manville Corporation, Manville, New Jersey. The appointment was announced by Lewis H. Brown, president of the corporation. Dr. Rassweiler was formerly head of the Philadelphia laboratory of E. I. du Pont de Nemours and Company.

Garland C. Richardson, Indian Territory Illuminating Oil Company at Bartlesville, was elected chairman of the Southwestern Section of the Society of Automotive Engineers at the annual meeting of that organization. Other officers elected are H. G. Bennett, Mid-Continent Petroleum Corporation, vice-chairman; W. F. Lowe, Natural Gasoline Association of America, secretary; Fred Hunt, Continental Oil Company, chairman of papers committee, and Carl Tangner, Diesel Power Company, chairman of membership committee.

Heath Renfro, chief engineer of the Corpus Christi district for the Texas Railroad Commission has been made petroleum engineer and assistant field superintendent in the Rio Grande Valley area by W. R. Davis, Inc. Renfro formerly was chief engineer in the Houston district for the commission.

Guy W. Wadsworth is now vice-president and director of Southern California Gas Company. E. N. Simmons, comptroller, was elected a member of the board.

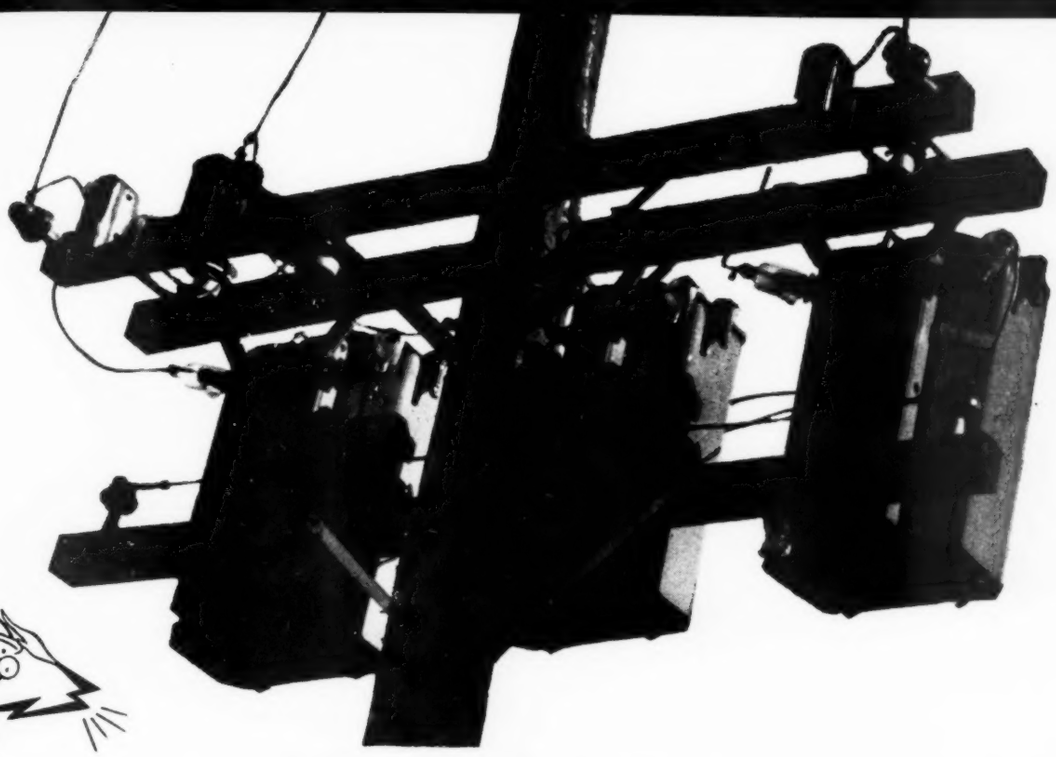
Victor Chancellor, Sinclair Prairie Oil Company, who has been district superintendent at Bairoil, Wyoming, has been transferred to Great Bend, Kansas.

L. B. Taylor, proration engineer in Kansas for Gulf Oil Corporation, has been employed as petroleum engineer in the conservation division by the Kansas Corporation Commission.

H. H. (Hap) Hensley, manager of the Valley Pipe Line Company at McAllen, Texas, built by the Murchison interests, will remain as manager under the new owners, the W. R. Davis, Inc.

R. L. (Bob) Keyes, formerly assistant manager of the California production department in Los Angeles, California, for The Texas Company, has been transferred to New Orleans, Louisiana.

J. B. Halstead is now superintendent of the new office of Sun Oil Company in Waycross, Georgia.



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Two well hook-up in Robbins Pool, Kansas, operated by Utility Electric Power. Depth of wells, 3,115 feet.

To our way of thinking, that which is defense for the Petroleum Industry is also defense for America and its people. Not defense against the threat of actual warfare alone, but defense against inefficiency and unprofitable operating costs. And defense in this sense is none other than Utility Electric Power. For with it you have the most modern and efficient type of power available to pump the shallowest or deepest well; to operate the biggest pipe line station; to operate the largest refinery; or to drill the deepest well. In fact, Utility Electric Power is your No. 1 defense weapon against outmoded power methods and practices, because it offers advantages not available with any other type of power. We have the facts to prove it. All we ask is the opportunity to show them to you. Why not ask us to help solve your power problems—now!

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• A careful study of the tremendous resources of the Utility Electric Power Companies throughout America reveal that there is a 40% reserve capacity of electric power available in excess of highest peak load requirements. This means READY power for Uncle Sam's many defense projects, and the release of READY CASH which can be spent for important defense projects other than electric power facilities.

PROFIT! BY USING Utility ELECTRIC POWER

The Petroleum Electric Power Association is the outgrowth of a desire on the part of Electric Power Companies to render greater service, through cooperative effort, to the Petroleum Industry.

Use Utility Electric Power!

PETROLEUM ELECTRIC POWER ASSOCIATION

LAUGH WITH BARNEY

A tourist returning to this country after a trip abroad was asked the usual question by the customs official: "Have you nothing to declare, Madam?"

"No," she replied sweetly, "nothing."

"Then, madam," said the official, "am I to understand that the fur tail hanging below your coat is your own?"

' ' '

I'm all done with dames
They cheat and they lie;
They prey on us males
To the day that we die.
They tease and torment us
And drive us to sin—
Say—Look at the blonde
That just came in.

' ' '

Golfer (far off in the rough): Say, caddy, why do you keep looking at your watch?

Caddy: It isn't a watch, sir, it's a compass.

' ' '

Said the skunk when the wind changed, "It all comes back to me now."

' ' '

Did you hear about the elephant that got so drunk he saw pink men?

' ' '

"You should place your hand over your mouth when you yawn."

"What? And get bit?"

' ' '

You heard about the old timer who thought when you pulled on the rayons the horse would stop.

' ' '

Employer: When I started in life, young man, I worked twelve hours a day.

Clerk: Yes, but in these rapid times any one who took twelve hours to do a day's work would get fired.

' ' '

A soldier went to his colonel and asked for leave to go home to help his wife with the spring housecleaning.

"I don't like to refuse you," said the colonel, "but I've just received a letter from your wife saying that you are no use around the house."

The soldier saluted and turned to go. At the door he stopped:

"Colonel, there are two persons in this regiment who handle the truth loosely, and I'm one of them. I'm not married."

' ' '

Love is one game that is never postponed on account of darkness.

An aged and very wrinkled old woman, arrayed in the calico costume of the mountains, was summoned as a witness in court to tell what she knew about a fight in her house. The Judge asked her in a kindly voice what took place. She insisted it did not amount to much, but the Judge by his persistency finally got her to tell the story of the bloody fracas.

"Now, I tell ye, Jedge, it didn't amount to nuthin'. The fust I knowed about it was when Bill Saunder called Tom Smith a liar, en Tom knocked him down with a stick o' wood. One o' Bill's friends then cut Tom with a knife, slicin' a big chunck out o' him. Then Sam Jones, who was a friend of Tom's, shot the other feller and two more shot him, en three or four others got cut right smart by somebody. That nachly caused some excitement, Jedge, en then they commenced fightin'."

' ' '

"Does your husband talk in his sleep?"

"No, and it's terribly exasperating. He just grins."

' ' '

A wildcat operator who was always talking in terms of thousands of dollars, was greeted one evening by his eleven-year-old son, who announced:

"Well, Dad, I've sold our dog."

"Yes, for how much?"

"Ten thousand dollars."

"Ten thousand dollars! Let's see the money!"

"I didn't get the money, Dad," replied the son, "I got two five thousand-dollar cats for it."

' ' '

Catherine: I shall spend my vacation fishing.

Beatrice: Then why the new bathing suit?

Catherine: That's my bait.

' ' '

He: Every time I kiss you it makes me a better man.

She: Well, you don't have to try to get to heaven in one night.

' ' '

A drunk got into a taxi and asked to be driven around the park five times. After the third round, the drunk shouted to the driver, "Fashter—I'm inna hurry."

' ' '

Teacher (in grammar class) Willie, please tell me what it is when I say 'I love, you love, he loves.'

Willie: That's one of them triangles where somebody gets shot.

The old-fashioned girl took two drinks and went out like a light; the modern girl takes two drinks and out goes the light.

' ' '

"Since Bill's marriage, he can't stand the sight of caviar."

"Doesn't that look like superstition?"

"No, it looks like buckshot."

' ' '

Interested old lady, questioning model: Do you mean to say you pose for a man with no clothes on?

Model: Heavens, no! He wears pants and everything.

' ' '

Tom: How do you like your new job selling on the road?

Harry: Oh, it's dandy. You meet some fine fellows at the hotels and have lots of fun in the evenings, but what I don't like is calling on those jobbers every day.

' ' '

The principal speaker of the evening was something of a bore. After he had been trying the patience of his hearers for 30 minutes, the chairman noticed that a diner on his right was snoring gently, tapped him lightly with his gavel.

A second time the diner dozed, and the gavel brought him back.

Again the snoring became audible and the chairman, losing patience, plied the gavel to more purpose.

"Go on," was the sleepy answer, "hit me again; I can still hear him."

' ' '

The inebriated gentleman staggered into the telegraph office and told the clerk he wanted to send a wire to George.

"George who?" asked the clerk.

"To George, thas all," muttered the drunk. "Jus good ol' George."

The clerk decided the only thing to do with the man was humor him. So he said: "All right. What do you want to say?"

"Just say tra la, tra la, tra la, tra la," replied the drunk.

"But that's only eight words," pointed out the clerk. "Don't you want to add another tra la and make it the usual 10-word message?"

"No," exclaimed the tipsy one. "I think that would be very silly."

' ' '

The haughty senior girl sniffed disdainfully as the tiny freshman cut in. "And just why did you have to cut in when I was dancing?" she inquired nastily.

The freshman hung his head in shame. "I'm sorry ma'am," he said, "but I'm working my way through college, and your partner was waving a five dollar bill at me."

THE *Petroleum* Engineer's

CONTINUOUS TABLES

A DAILY REFERENCE FOR OPERATING MEN

INSTALLMENT No. 48

To aid the reader in using the Decimal system of filing, a subject index arranged alphabetically has been published, and is available at a cost of 50 cents per copy from *The Petroleum Engineer*, P. O. Box 1589, Dallas, Texas.

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RISE IN FLUID LEVEL, ETC., DUE TO RUNNING 2-IN. EXTERNAL-UPSET TUBING IN WELL FLUID

Diameter of outer string or open hole, in.	Internal diameter of outer string or open hole, in.	Volume[1] contained in outer string or open hole		Volume[1] contained in annular space		Volume[1] in well bore when tubing is in hole (volume in annulus plus volume in tubing)		For every 100 ft. of tubing run in fluid, fluid level will be raised:	
		gal.	bbl.	gal.	bbl.	gal.	bbl.	in annular space when lower end of tubing is closed, ft.-in.	in well bore when lower end of tubing is open, ft.-in.
Tubing strings[2]									
Non-upset									
3½	3.548	51.36	1.223	28.03	0.667	44.27	1.054	83- 3	1- 7
4	3.958	63.92	1.522	40.59	.966	56.83	1.353	57- 6	1- 3
Upset									
3½	3.476	49.30	1.174	25.97	0.618	42.21	1.005	89-10	1- 8
4	3.958	63.92	1.522	40.59	.966	56.83	1.353	57- 6	1- 3
Casing strings[2]									
4½	4.090	68.25	1.625	44.92	1.070	61.16	1.456	51- 1	1- 2
4½	3.920	62.69	1.493	39.36	0.937	55.60	1.324	59- 3	1- 3
5	4.560	84.84	2.020	61.51	1.465	77.75	1.851	37-11	0-11
5	4.276	74.60	1.776	51.27	1.221	67.51	1.607	45- 6	1-1
5½	5.044	103.8	2.471	80.47	1.916	96.71	2.303	29- 0	0- 9
5½	4.670	88.98	2.119	65.65	1.563	81.89	1.950	35- 6	0-10
6	5.524	124.5	2.964	101.2	2.410	117.4	2.795	23- 1	0- 7
6	5.240	112.0	2.667	88.67	2.111	104.9	2.498	19- 9	0- 8
6⅝	6.135	153.6	3.657	130.3	3.102	146.5	3.488	17-11	0- 6
6⅝	5.675	131.4	3.129	108.1	2.574	124.3	2.960	21- 7	0- 7
7	6.538	174.4	4.152	151.1	3.598	167.3	3.983	15- 5	0- 5
7	5.920	143.0	3.405	119.7	2.850	135.9	3.236	19- 6	0- 6
7⅝	7.125	207.1	4.931	183.8	4.376	200.0	4.762	12- 8	0- 4
7⅝	6.625	179.1	4.624	155.8	3.710	172.0	4.095	15- 0	0- 5
8⅝	8.097	267.5	6.369	244.2	5.814	260.4	6.200	9- 7	0- 3
8⅝	7.511	230.2	5.481	206.9	4.926	223.1	5.312	11- 3	0- 4
9⅝	9.063	335.1	7.979	311.8	7.424	328.0	7.810	7- 6	0- 3
9⅝	8.535	297.2	7.076	273.9	6.521	290.1	6.907	8- 6	0- 3
10¾	10.192	423.8	10.090	400.5	9.536	416.7	9.921	5-10	0- 2
10¾	9.760	388.7	9.255	365.4	8.700	381.6	9.086	6- 5	0- 2
11¾	11.150	507.2	12.076	483.9	11.521	500.1	11.907	4-10	0 -2
11¾	10.772	473.4	11.271	450.1	10.717	466.3	11.102	5- 2	0- 2
13⅜	12.715	659.6	15.705	636.3	15.150	652.5	15.536	3- 8	0- 1(+)
13⅜	12.347	622.0	14.810	598.7	14.255	614.9	14.640	3-11	0- 1(+)
Open hole (bit size)[3]									
3⅞	3.875	61.27	1.459	37.94	0.903	54.18	1.290	61- 6	1- 4
4¼	4.250	73.70	1.755	50.37	1.199	66.61	1.586	46- 4	1- 1
4¾	4.750	92.06	2.192	68.73	1.636	84.97	2.023	33-11	0-10
5⅝	5.625	131.4	3.129	108.1	2.574	124.3	2.960	21- 7	0- 7
6	6.000	146.9	3.498	123.6	2.943	139.8	3.329	18-11	0- 6
6⅛	6.125	153.1	3.645	129.8	3.090	146.0	3.476	18- 0	0- 6
6½	6.500	172.4	4.105	149.1	3.550	165.3	3.936	15- 8	0- 5
6¾	6.750	185.9	4.426	162.6	3.871	178.8	4.257	14- 4	0- 5
7	7.000	199.9	4.760	176.6	4.205	192.8	4.590	13- 3	0- 4
7½[4]	7.500	229.5	5.464	206.2	4.910	222.4	5.295	11- 9	0- 4
7¾[4]	7.750	245.1	5.836	221.8	5.281	238.0	5.667	10- 6	0- 4
8½[4]	8.500	294.8	7.019	271.5	6.464	287.7	6.850	8- 7	0 -3
9¾[4]	9.750	387.9	9.236	364.6	8.681	380.8	9.067	6- 5	0- 2
10⅝	10.625	460.6	10.967	437.3	10.412	453.5	10.798	5- 4	0- 2

The 2-in. external-upset tubing has a calculated weight of 4.63 lb. per ft. (including a coupling spaced every 20 ft.). The volume displaced by 100 ft. of tubing and 5 couplings; (1) by the steel itself (with lower end of tubing open), 0.7075 gal. or 0.01685 bbl.; (2) by the pipe (with lower end of tubing closed), 23.33 gal. or 0.5554 bbl. The volume contained within 100 ft. of the tubing is 16.238 gal. or 0.3866 bbl.

[1]All volume figures are based on 100 ft. of depth; multiply to convert to other depths or lengths. For example, if the depth or length is 5196 ft., multiply by 51.96.

[2]Only maximum and minimum weights of pipe are shown for each casing size.

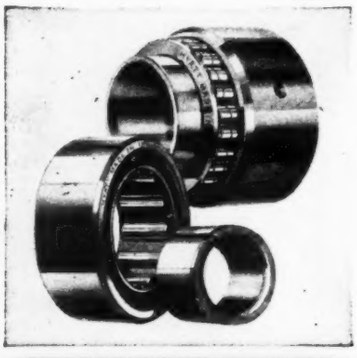
[3]Variation in diameter of open hole due to caving, etc., is disregarded.

[4]This diameter is an average of the two bit sizes ⅛ in. larger and smaller, respectively.

Table suggested by George B. Rice, Butler & Horne Drilling Co., Dallas, Texas.

KEEP THEM YOUNG WITH HYATTS

BETHLEHEM PUMPING UNITS are designed scientifically to lower lifting costs. Naturally they, too, are Hyatt equipped.



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HYATT

ROLLER BEARINGS

QUIET

CORRELATION INDEX[1(a)] (C. I.) VALUES IN CRUDE-OIL ANALYSES[2]

Specific gravity, G, of fraction at 60°F/60°F	Fraction no.[3]	Constant for fraction[4]	Temperature limits of fraction, °C.	Average volumetric boiling point[5] of fraction, °K	Correlation index (C. I.) values — Specific gravity—third decimal place									
					0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.007	0.008	0.009
0.860	7	394.4	175–200	453	58.	58.	59.	59.	60.	60.	61.	61.	62.	62.
.860	8	355.0	200–225	478	52.	53.	53.	54.	54.	55.	55.	56.	56.	57.
.860	9	360.3	225–250	504	47.	48.	48.	49.	49.	50.	50.	50.	51.	51.
.860	10	365.0	250–275	530	42.	43.	43.	44.	44.	45.	45.	46.	46.	47.
0.860	11	369.0	To 200[6]	554[7]	38.	39.	39.	40.	40.	41.	41.	42.	42.	43.
.860	12	372.8	200–225	579	35.	35.	36.	36.	37.	37.	37.	38.	38.	39.
.860	13	376.1	225–250	603	31.	32.	32.	33.	33.	34.	34.	35.	35.	36.
.860	14	379.3	250–275	628	28.	29.	29.	30.	30.	31.	31.	31.	32.	32.
.860	15	382.3	275–300	653	25.	26.	26.	27.	27.	28.	28.	28.	29.	29.
0.870	8				57.	58.	58.	59.	59.	60.	60.	60.	61.	61.
.870	9				52.	52.	53.	53.	54.	54.	55.	55.	56.	56.
.870	10				47.	48.	48.	49.	49.	50.	50.	50.	51.	51.
.870	11				43.	44.	44.	45.	45.	46.	46.	46.	47.	47.
0.870	12				39.	40.	40.	41.	41.	42.	42.	43.	43.	44.
.870	13				36.	37.	37.	37.	38.	38.	39.	39.	40.	40.
.870	14				33.	33.	34.	34.	35.	35.	36.	36.	37.	37.
.870	15				30.	30.	31.	31.	32.	32.	33.	33.	34.	34.
0.880	8				62.	62.	63.	63.	64.	64.	65.	65.	66.	66.
.880	9				57.	57.	58.	58.	59.	59.	59.	60.	60.	61.
.880	10				52.	52.	53.	53.	54.	54.	55.	55.	56.	56.
.880	11				48.	48.	49.	49.	50.	50.	51.	51.	52.	52.
0.880	12				44.	45.	45.	46.	46.	46.	47.	47.	48.	48.
.880	13				41.	41.	42.	42.	43.	43.	44.	44.	45.	45.
.880	14				38.	38.	39.	39.	40.	40.	40.	41.	41.	42.
.880	15				35.	35.	36.	36.	37.	37.	37.	38.	38.	39.
0.890	8				67.	67.	68.	68.	69.	69.	69.	70.	70.	71.
.890	9				61.	62.	62.	63.	63.	64.	64.	65.	65.	66.
.890	10				57.	57.	58.	58.	59.	59.	59.	60.	60.	61.
.890	11				53.	53.	54.	54.	55.	55.	55.	56.	56.	57.
0.890	12				49.	49.	50.	50.	51.	51.	52.	52.	53.	53.
.890	13				46.	46.	46.	47.	47.	48.	48.	49.	49.	50.
.890	14				42.	43.	43.	44.	44.	45.	45.	46.	46.	47.
.890	15				39.	40.	40.	41.	41.	42.	42.	43.	43.	44.
0.900	10				61.	62.	62.	63.	63.	64.	64.	65.	65.	66.
.900	11				57.	58.	58.	59.	59.	60.	60.	61.	61.	62.
.900	12				54.	54.	55.	55.	55.	56.	56.	57.	57.	58.
.900	13				50.	51.	51.	52.	52.	53.	53.	54.	54.	55.
.900	14				47.	48.	48.	49.	49.	49.	50.	50.	51.	51.
.900	15				44.	45.	45.	46.	46.	46.	47.	47.	48.	48.
0.910	11				62.	63.	63.	64.	64.	64.	65.	65.	66.	66.
.910	12				58.	59.	59.	60.	60.	61.	61.	62.	62.	63.
.910	13				55.	55.	56.	56.	57.	57.	58.	58.	59.	59.
.910	14				52.	52.	53.	53.	54.	54.	55.	55.	56.	56.
.910	15				49.	49.	50.	50.	51.	51.	52.	52.	53.	53.
0.920	11				67.	67.	68.	68.	69.	69.	70.	70.	71.	71.
.920	12				63.	64.	64.	64.	65.	65.	66.	66.	67.	67.
.920	13				60.	60.	61.	61.	62.	62.	63.	63.	64.	64.
.920	14				57.	57.	58.	58.	58.	59.	59.	60.	60.	61.
.920	15				54.	54.	55.	55.	55.	56.	56.	57.	57.	58.
0.930	11				71.	72.	72.	73.	73.	74.	74.	75.	75.	76.
.930	12				68.	68.	69.	69.	70.	70.	71.	71.	72.	72.
.930	13				64.	65.	65.	66.	66.	67.	67.	68.	68.	69.
.930	14				61.	62.	62.	63.	63.	64.	64.	65.	65.	66.
.930	15				58.	59.	59.	60.	60.	61.	61.	62.	62.	63.
0.940	12				73.	73.	73.	74.	74.	75.	75.	76.	76.	77.
.940	13				69.	70.	70.	71.	71.	72.	72.	73.	73.	73.
.940	14				66.	67.	67.	67.	68.	68.	69.	69.	70.	70.
.940	15				63.	64.	64.	64.	65.	65.	66.	66.	67.	67.
0.950	12				77.	78.	78.	79.	79.	80.	80.	81.	81.	82.
.950	13				74.	74.	75.	75.	76.	76.	77.	77.	78.	78.
.950	14				71.	71.	72.	72.	73.	73.	74.	74.	75.	75.
.950	15				68.	68.	69.	69.	70.	70.	71.	71.	72.	72.
0.960	13				79.	79.	80.	80.	81.	81.	82.	82.	82.	83.
.960	14				76.	76.	76.	77.	77.	78.	78.	79.	79.	80.
.960	15				73.	73.	73.	74.	74.	75.	75.	76.	76.	77.
0.970	14				80.	81.	81.	82.	82.	83.	83.	84.	84.	85.
.970	15				77.	78.	78.	79.	79.	80.	80.	81.	81.	82.
0.980	14				85.	85.	86.	86.	87.	87.	88.	88.	89.	89.
.980	15				82.	82.	83.	83.	84.	84.	85.	85.	86.	86.
0.990	15				87.	87.	88.	88.	89.	89.	90.	90.	91.	91.

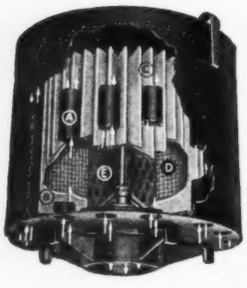
(a) For explanatory notes see sheet 1, P 721.02.

STAYNEW FILTERS

What Does the Name "STAYNEW" Mean? » » » » » » » »

1. Less Wear on Engines and Compressors
2. More Service from Air-Powered Tools
3. Longer Lasting Filters

ENGINE AND EQUIPMENT-SAVING FILTERS FOR INDUSTRY

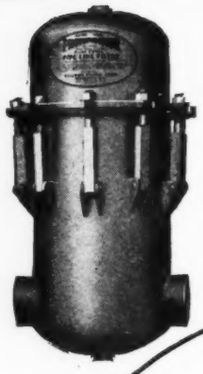


For Engine Protection

Models D, DS: Permit only clean, dust-free air to be drawn into engine and compressor intake. Model DS features rectifying tubes of scientific *diameter to length ratio* that "quiets the thump that hurts your ears." Feltex Filtering Medium in Radial Fin Construction provides greatest possible filtering area and efficiency with *permanently* low restriction to air flow. D and DS Protectomotors make new engines and compressors *stay new*—add to life and efficiency of old ones.

For Compressed Air and Gas Lines

Models CP, CPH: Hundreds of thousands in use throughout industry. Guaranteed delivery of clean, dry air, free from dust, dirt, pipe-scale, rust, water. All air-powered tools operate more efficiently, last longer when air supply is kept clean with Protectomotor Pipe Line Filters. Protectomotors often save their cost in a few months. Like all Staynew and Protectomotor filters—easy to inspect, easy to clean, low restriction to air flow, long lasting. Models for horizontal and vertical installation.



For Liquid Lines (Incl. Water)

Models CPHL, CPHLS: Famous Radial Fin Construction applied to the filtration of liquids. Fuel and lubricating oil models remove abrasive matter from oil lines for engines and compressors, preventing excessive wear of all parts lubricated by crankcase oil system; prevent, also, clogging and wear of fuel nozzles. All parts *stay new* longer. Swing-bolted head if required.

NEW WATER FILTER: An outstanding success everywhere. Used in scores of applications where pure filtered water is a necessity.

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Just off the press, 44 pages. Valuable engineering data, charts and specifications. Catalog describes in complete detail Staynew and Protectomotor engine and equipment saving features: Radial Fin Construction—Feltex and Glastex Filtering Mediums—*Double* Counter-clockwise Rotating Curtains—Fire-resistant Wire-Kladding, etc. Description of entire line includes filters for building ventilation. Staynew filters speed production, save money. Write for catalog today.

PROTECTOMOTOR 99 44/100 Per Cent EFFICIENCY AIR FILTERS

STAYNEW FILTER CORP.

2 Leighton Ave., Rochester, N. Y. *"Filter Headquarters"*

Static Press.
800-895 lb.

PRESSURE EXTENSIONS—ORIFICE METER CALCULATIONS

Differential pressure, in. of water	Static pressure, lb. per sq. in., ga.																			
	800	805	810	815	820	825	830	835	840	845	850	855	860	865	870	875	880	885	890	895
2	40.37	40.50	40.61	40.74	40.86	40.98	41.10	41.22	41.35	41.47	41.59	41.71	41.83	41.94	42.07	42.18	42.31	42.42	42.53	42.66
4	57.10	57.28	57.44	57.62	57.80	57.96	58.14	58.30	58.48	58.66	58.82	59.00	59.16	59.32	59.50	59.66	59.84	60.00	60.16	60.34
6	69.92	70.14	70.34	70.56	70.78	70.97	71.19	71.39	71.61	71.83	72.03	72.25	72.44	72.64	72.86	73.05	73.27	73.47	73.67	73.89
8	80.74	80.99	81.22	81.47	81.73	81.96	82.21	82.44	82.69	82.95	83.17	83.43	83.65	83.88	84.13	84.36	84.61	84.84	85.07	85.32
10	90.28	90.56	90.81	91.10	91.38	91.63	91.92	92.17	92.46	92.74	92.99	93.28	93.53	93.78	94.07	94.32	94.61	94.86	95.11	95.40
12	98.90	99.21	99.49	99.80	100.1	100.4	100.7	101.0	101.3	101.6	101.9	102.2	102.5	102.7	103.1	103.3	103.6	103.9	104.2	104.5
14	106.8	107.2	107.5	107.8	108.1	108.4	108.8	109.1	109.4	109.8	110.1	110.4	110.7	111.0	111.3	111.6	112.0	112.3	112.6	112.9
16	114.2	114.6	114.9	115.2	115.6	115.9	116.3	116.6	117.0	117.3	117.6	118.0	118.3	118.6	119.0	119.3	119.7	120.0	120.3	120.7
18	121.1	121.5	121.9	122.2	122.6	123.0	123.3	123.7	124.1	124.4	124.8	125.2	125.5	125.8	126.2	126.6	127.0	127.3	127.6	128.0
20	127.7	128.1	128.4	128.8	129.2	129.6	130.0	130.4	130.8	131.2	131.5	131.9	132.3	132.6	133.0	133.4	133.8	134.2	134.5	134.9
21	130.8	131.3	131.6	132.0	132.4	132.8	133.2	133.6	134.0	134.4	134.8	135.2	135.6	135.9	136.3	136.7	137.1	137.5	137.9	138.3
22	133.9	134.3	134.7	135.1	135.5	135.9	136.3	136.7	137.1	137.6	137.9	138.4	138.7	139.1	139.5	139.9	140.3	140.7	141.1	141.5
23	136.9	137.4	137.7	138.2	138.6	138.9	139.4	139.8	140.2	140.7	141.1	141.5	141.9	142.2	142.7	143.1	143.5	143.9	144.3	144.7
24	139.9	140.3	140.7	141.1	141.6	142.0	142.4	142.8	143.2	143.7	144.1	144.5	144.9	145.3	145.7	146.1	146.6	147.0	147.4	147.8
25	142.8	143.2	143.6	144.1	144.5	144.9	145.4	145.8	146.2	146.7	147.1	147.5	147.9	148.3	148.8	149.2	149.6	150.0	150.4	150.9
26	145.6	146.0	146.4	146.9	147.4	147.8	148.2	148.6	149.1	149.6	150.0	150.4	150.8	151.2	151.7	152.1	152.6	153.0	153.4	153.8
27	148.3	148.8	149.2	149.7	150.2	150.6	151.0	151.5	151.9	152.4	152.8	153.3	153.7	154.1	154.6	155.0	155.5	155.9	156.3	156.8
28	151.1	151.6	152.0	152.5	152.9	153.4	153.8	154.3	154.7	155.2	155.6	156.1	156.5	157.0	157.4	157.9	158.3	158.8	159.2	159.7
29	153.7	154.2	154.7	155.1	155.6	156.1	156.5	157.0	157.5	157.9	158.4	158.9	159.3	159.7	160.2	160.6	161.1	161.6	162.0	162.5
30	156.4	156.9	157.3	157.8	158.3	158.7	159.2	159.7	160.1	160.6	161.1	161.6	162.0	162.4	162.9	163.4	163.9	164.3	164.7	165.2
31	159.0	159.5	159.9	160.4	160.9	161.4	161.9	162.3	162.8	163.3	163.8	164.3	164.7	165.1	165.6	166.1	166.6	167.0	167.5	168.0
32	161.5	162.0	162.5	163.0	163.5	163.9	164.4	164.9	165.4	165.9	166.4	166.9	167.3	167.8	168.3	168.7	169.3	169.7	170.2	170.7
33	164.0	164.5	165.0	165.5	166.0	166.5	167.0	167.5	168.0	168.5	169.0	169.5	169.9	170.4	170.9	171.4	171.9	172.4	172.8	173.3
34	166.5	167.0	167.5	168.0	168.5	169.0	169.5	170.0	170.5	171.0	171.5	172.0	172.5	172.9	173.5	173.9	174.5	174.9	175.4	175.9
35	168.9	169.4	169.9	170.4	171.0	171.4	172.0	172.5	173.0	173.5	174.0	174.5	175.0	175.5	176.0	176.5	177.0	177.5	178.0	178.5
36	171.3	171.8	172.3	172.9	173.4	173.9	174.4	174.9	175.4	176.0	176.5	177.0	177.5	178.0	178.5	179.0	179.5	180.0	180.5	181.0
37	173.7	174.2	174.7	175.3	175.8	176.3	176.8	177.3	177.9	178.4	178.9	179.4	179.9	180.4	181.0	181.5	182.0	182.5	183.0	183.5
38	176.0	176.5	177.0	177.6	178.1	178.6	179.2	179.7	180.2	180.8	181.3	181.8	182.3	182.8	183.4	183.9	184.4	184.9	185.4	186.0
39	178.3	178.9	179.4	179.9	180.5	181.0	181.5	182.0	182.6	183.2	183.7	184.2	184.7	185.2	185.8	186.3	186.9	187.4	187.8	188.4
40	180.6	181.1	181.7	182.2	182.8	183.3	183.9	184.4	184.9	185.5	186.0	186.6	187.1	187.6	188.2	188.7	189.2	189.8	190.3	190.8
41	182.8	183.4	183.9	184.5	185.0	185.6	186.1	186.6	187.2	187.8	188.3	188.9	189.4	189.9	190.5	191.0	191.6	192.1	192.6	193.2
42	185.0	185.6	186.1	186.7	187.3	187.8	188.4	188.9	189.5	190.1	190.6	191.2	191.7	192.2	192.8	193.3	193.9	194.4	194.9	195.5
43	187.2	187.8	188.3	188.9	189.5	190.0	190.6	191.1	191.7	192.3	192.8	193.4	194.0	194.5	195.1	195.6	196.2	196.7	197.2	197.8
44	189.4	190.0	190.5	191.1	191.7	192.2	192.8	193.4	193.9	194.5	195.1	195.7	196.2	196.7	197.3	197.9	198.5	199.0	199.5	200.1
45	191.5	192.1	192.7	193.3	193.9	194.4	195.0	195.5	196.1	196.7	197.3	197.9	198.4	199.0	199.6	200.1	200.7	201.2	201.8	202.4
46	193.6	194.2	194.8	195.4	196.0	196.5	197.2	197.7	198.3	198.9	199.5	200.1	200.6	201.2	201.8	202.3	202.9	203.5	204.0	204.6
47	195.7	196.4	196.9	197.5	198.1	198.7	199.3	199.9	200.5	201.1	201.6	202.3	202.8	203.3	204.0	204.5	205.1	205.7	206.2	206.8
48	197.8	198.4	199.0	199.6	200.2	200.8	201.4	202.0	202.6	203.2	203.8	204.4	204.9	205.5	206.1	206.7	207.3	207.8	208.4	209.0
49	199.9	200.5	201.0	201.7	202.3	202.9	203.5	204.1	204.7	205.3	205.9	206.5	207.1	207.6	208.3	208.8	209.4	210.0	210.6	211.2
50	201.9	202.5	203.1	203.7	204.4	204.9	205.6	206.1	206.8	207.4	208.0	208.6	209.2	209.7	210.4	210.9	211.6	212.1	212.7	213.3
51	203.9	204.5	205.1	205.7	206.4	206.9	207.6	208.2	208.8	209.4	210.0	210.7	211.2	211.8	212.4	213.0	213.7	214.2	214.8	215.4
52	205.9	206.5	207.1	207.7	208.4	209.0	209.6	210.2	210.8	211.5	212.1	212.7	213.3	213.9	214.5	215.1	215.8	216.3	216.9	217.6
53	207.8	208.5	209.1	209.7	210.4	211.0	211.6	212.2	212.9	213.5	214.1	214.8	215.3	215.9	216.6	217.2	217.8	218.4	219.0	219.6
54	209.8	210.4	211.0	211.7	212.4	212.9	213.6	214.2	214.9	215.5	216.1	216.8	217.4	217.9	218.6	219.2	219.9	220.4	221.0	221.7
55	211.7	212.4	213.0	213.7	214.3	214.9	215.6	216.2	216.8	217.5	218.1	218.8	219.4	220.0	220.6	221.2	221.9	222.5	223.1	223.7
56	213.6	214.3	214.9	215.6	216.3	216.9	217.5	218.1	218.8	219.5	220.1	220.7	221.3	221.9	222.6	223.2	223.9	224.5	225.1	225.8
57	215.6	216.2	216.8	217.5	218.2	218.8	219.5	220.1	220.8	221.4	222.0	222.7	223.3	223.9	224.6	225.2	225.9	226.5	227.1	227.8
58	217.4	218.1	218.7	219.4	220.1	220.7	221.4	222.0	222.7	223.4	224.0	224.7	225.3	225.9	226.6	227.2	227.9	228.5	229.1	229.8
59	219.3	220.0	220.6	221.3	222.0	222.6	223.3	223.9	224.6	225.3	225.9	226.6	227.2	227.8	228.5	229.1	229.8	230.4	231.0	231.7
60	221.1	221.8	222.5	223.2	223.9	224.5	225.2	225.8	226.5	227.2	227.8	228.5	229.1	229.7	230.4	231.1	231.8	232.4	233.1	233.7
61	223.0	223.7	224.3	225.0	225.7	226.3	227.0	227.7	228.4	229.1	229.7	230.4	231.0	231.6	232.3	233.0	233.7	234.3	234.9	235.6
62	224.8	225.5	226.1	226.8	227.6	228.2	228.9	229.5	230.2	230.9	231.6	232.3	232.9	233.5	234.3	234.9	235.6	236.2	236.8	237.6
63	226.6	227.3	228.0	228.7	229.4	230.0	230.7	231.4	232.1	232.8	233.4	234.1	234.8	235.4	236.1	236.8	237.5	238.1	238.7	239.5
64	228.4	229.1	229.8	230.5	231.2	231.8	232.6	233.2	233.9	234.6	235.3	236.0	236.6	237.3	238.0	238.6	239.4	240.0	240.6	241.4
65	230.2	230.9	231.5	232.3	233.0	233.6	234.4	235.0	235.7	236.5	237.1	237.8	238.5	239.1	239.8	240.5	241.2	241.9	242.5	243.2
66	231.9	232.7	233.3	234.1	234.8	235.4	236.2	236.8	237.5	238.3	238.9	239.7	240.3	241.0	241.7	242.3	243.1	243.7	244.4	245.1
67	233.7	234.4	235.1	235.8	236.5	237.2	237.9	238.6	239.3	240.1	240.7	241.5	242.1	242.8	243.5	244.2	244.9	245.6	246.2	246.9
68	235.4	236.2	236.8	237.6	238.3	239.0	239.7	240.4	241.1	241.9	242.5	243.3	243.9	244.6	245.3	246.0	246.7	247.4	248.0	248.8
69	237.2	237.9	238.6	239.3	240.1	240.7	241.5	242.1	242.9	243.6	244.3	245.1	245.7	246.4	247.1	247.8	248.5	249.2	249.9	250.6
70	238.9	239.6	240.3	241.1	241.8	242.5	243.2	243.9	244.7	245.4	246.1	246.8	247.5	248.2	248.9	249.6	250.3	251.0	251.7	252.4
71	240.6	241.3	242.0	242.8	243.5	244.2	244.9	245.6	246.4	247.1	247.8	248.6	249.2	249.9	250.7	251.3	252.1	252.8	253.5	254.2
72	242.2	243.0	243.7	244.5	245.2	245.9	246.7	247.3	248.1	248.9	249.5	250.3	251.0	251.7	252.4	253.1	253.9	254.6	255.2	256.0
73	243.9	244.7	245.4	246.2	246.9	247.6	248.4	249.1	249.8	250.6	251.3	252.0	252.7	253.4	254.2	254.9	255.6	256.3	257.0	257.8
74	245.6	246.4	247.0	247.8	248.6	249.3	250.1	250.7	251.5	252.3	253.0	253.8	254.4	255.1	255.9	256.6	257.4	258.1	258.7	259.5
75	247.2	248.0	248.7	249.5	250.3	251.0	251.7	252.4	253.2	254.0	254.7	255.5	256.2	256.9	257.6	258.3	259.1	259.8	260.5	261.3
76	248.9	249.7	250.4	251.2	252.0	252.6	253.4	254.1	254.9	255.7	256.4	257.2	257.9	258.6	259.4	260.1	260.8	261.5	262.2	263.0
77	250.5	251.3	252.0	252.8	253.6	254.3	255.1	255.8	256.6	257.4	258.1	258.9	259.6	260.3	261.1	261.8	262.5	263.3	264.0	264.7
78	252.2	252.9	253.7	254.4	255.2	256.0	256.7	257.5	258.2	259.0	259.7	260.5	261.3	262.0	262.8	263.5	264.3	265.0	265.7	266.5
79	253.8	254.6	255.3	256.1	256.9	257.6	258.4	259.1	259.9	260.7	261.4	262.2	262.9	263.6	264.4	265.1	265.9	266.6	267.4	268.2
80	255.4	256.2	256.9	257.7	258.5	259.2	260.0	260.7	261.5	262.3	263.0	263.8	264.6	265.3	266.1	266.8	267.6	268.3	269.0	269.8
82	258.5	259.3	260.1	260.9	261.7	262.4	263.2	264.0	264.8	265.6	266.3	267.1	267.8	268.6	269.4	270.1	270.9	271.7	272.4	273.2
84	261.7	262.5	263.2	264.0	264.9	265.6	266.4	267.2	268.0	268.8	269.5	270.4	271.1	271.8	272.7	273.4	274.2	275.0	275.7	276.5
86	264.8	265.6	266.3	267.2	268.0	268.8	269.6	270.3	271.2	272.0	272.7	273.6	274.3	275.1	275.9	276.6	277.5	278.2	279.0	279.8
88	267.8	268.7	269.4	270.3	271.1	271.9	272.7	273.5	274.3	275.1	275.9	276.7	277.5	278.2	279.1	279.8	280.7	281.4	282.2	283.0
90	270.9	271.7	272.5	273.3	274.2	274.9	275.8	276.5	277.4	278.3	279.0	279.9	280.6	281.4	282.2	283.0	283.9	284.6	285.4	286.2
92	273.9	274.7	275.5	276.3	277.2	278.0	278.8	279.6	280.5	281.3	282.1	283.0	283.7	284.5	285.4	286.1	287.0	287.8	288.5	289.4
94	276.8	277.7	278.4	279.3	280.2	281.0	281.8	282.6	283.5	284.4	285.1	286.0	286.8	287.6	288.4	289.2	290.1	290.9	291.6	292.5
96	279.7	280.6	281.4	282.3	283.2	283.9	284.8	285.6	286.5	287.4	288.2	289.0	289.8	290.6	291.5	292.3	293.2	293.9	294.7	295.6
98	282.6	283.5	284.3	285.3	286.1	286.9	287.8	288.6	289.4	290.3	291.1	292.0	292.8	293.6	294.5	295.3	296.2	297.0	297.8	298.7
100	285.5	286.4	287.2	288.1	289.0	289.8	290.7	291.5	292.4	293.3	294.1	295.0	295.8	296.6	297.5	298.3	299.2	300.0	300.8	301.7

NOTE: Values given in body of table are products of the square roots of the static and differential pressures in lb. per sq. in., abs., and inches of water respectively.

Absolute pressures are based on atmospheric pressure of 15 lb. per sq. in.

Table has been condensed to serve field men in approximating meter readings; intermediate readings for accurate measurements may be obtained from pressure extension books, usually available in district offices.

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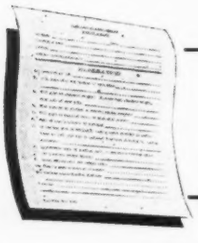

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VELOCITY[1] OF FLOW, FT. PER SEC., THROUGH ANNULUS BETWEEN 2½-IN. AND 4-IN. TUBING

Rate of production, bbl. per day	Gas-oil ratio, cu. ft. per bbl.	Tubing pressure[2] at casinghead, lb. per sq. in. gauge								
		0	25	50	75	100	125	150	175	200
50	300	4.4	1.7	1.1	0.8	0.6	0.5	0.5	0.4	0.4
100		8.8	3.4	2.1	1.6	1.3	1.1	0.9	0.8	0.8
150		13.1	5.1	3.2	2.4	1.9	1.6	1.4	1.3	1.1
200		17.5	6.8	4.3	3.2	2.6	2.2	1.9	1.7	1.5
250		21.9	8.5	5.4	4.0	3.2	2.7	2.4	2.1	1.9
300		26.3	10.2	6.4	4.8	3.8	3.2	2.8	2.5	2.3
350		30.7	11.9	7.5	5.6	4.5	3.8	3.3	2.9	2.7
400		35.1	13.5	8.6	6.4	5.1	4.3	3.8	3.4	3.0
50	400	5.8	2.2	1.4	1.0	0.8	0.7	0.6	0.5	0.5
100		11.6	4.5	2.8	2.1	1.7	1.4	1.2	1.1	1.0
150		17.4	6.7	4.2	3.1	2.5	2.1	1.8	1.6	1.4
200		23.3	8.9	5.6	4.1	3.3	2.8	2.4	2.1	1.9
250		29.1	11.2	7.0	5.2	4.1	3.5	3.0	2.7	2.4
300		34.9	13.4	8.4	6.2	5.0	4.2	3.6	3.2	2.9
350		40.7	15.6	9.8	7.3	5.8	4.9	4.2	3.7	3.4
400		46.5	17.8	11.2	8.3	6.6	5.6	4.8	4.3	3.8
50	500	7.2	2.7	1.7	1.3	1.0	0.8	0.7	0.6	0.6
100		14.5	5.5	3.5	2.6	2.0	1.7	1.5	1.3	1.2
150		21.7	8.2	5.2	3.8	3.0	2.5	2.2	1.9	1.7
200		29.0	11.0	6.9	5.1	4.1	3.4	2.9	2.6	2.3
250		36.2	13.7	8.7	6.4	5.1	4.2	3.7	3.2	2.9
300		43.5	16.5	10.4	7.7	6.1	5.1	4.4	3.9	3.5
350		50.7	19.2	12.1	8.9	7.1	5.9	5.1	4.5	4.1
400		58.0	22.0	13.9	10.2	8.1	6.8	5.9	5.2	4.6
50	600	8.7	3.3	2.1	1.5	1.2	0.8	0.7	0.6	0.6
100		17.4	6.6	4.1	3.0	2.4	1.7	1.5	1.3	1.2
150		26.1	9.9	6.2	4.5	3.6	2.5	2.2	1.9	1.7
200		34.7	13.2	8.3	6.1	4.8	3.4	2.9	2.6	2.3
250		43.4	16.5	10.3	7.6	6.0	4.2	3.7	3.2	2.9
300		52.1	19.8	12.4	9.1	7.2	5.1	4.4	3.9	3.5
350		60.8	23.1	14.5	10.6	8.4	5.9	5.1	4.5	4.1
400		69.5	26.5	16.5	12.1	9.6	6.8	5.9	5.2	4.6
50	700	10.1	3.8	2.4	1.8	1.4	1.2	1.0	0.8	0.7
100		20.2	7.7	4.8	3.5	2.8	2.3	2.0	1.5	1.4
150		30.4	11.5	7.2	5.3	4.2	3.5	3.0	2.3	2.0
200		40.5	15.4	9.6	7.0	5.6	4.6	4.0	3.0	2.7
250		50.6	19.2	12.0	8.8	6.9	5.8	5.0	3.8	3.4
300		60.7	23.1	14.4	10.5	8.3	6.9	6.0	4.6	4.1
350		70.8	26.9	16.8	12.3	9.7	8.1	7.0	5.3	4.8
400		80.9	30.8	19.2	14.0	11.1	9.2	7.9	6.1	5.4
50	800	11.6	4.4	2.7	2.0	1.6	1.3	1.1	1.0	0.9
100		23.1	8.8	5.5	4.0	3.2	2.6	2.2	2.0	1.8
150		34.7	13.1	8.2	6.0	4.7	3.9	3.4	3.0	2.6
200		46.2	17.5	10.9	8.0	6.3	5.2	4.5	3.9	3.5
250		57.8	21.9	13.6	10.0	7.9	6.5	5.6	4.9	4.4
300		69.3	26.3	16.4	12.0	9.5	7.9	6.7	5.9	5.3
350		80.9	30.7	19.1	14.0	11.0	9.2	7.9	6.9	6.2
400		92.4	35.1	21.8	15.9	12.6	10.5	9.0	7.9	7.0
50	900	13.0	4.9	3.1	2.2	1.8	1.5	1.3	1.1	1.0
100		26.0	9.8	6.1	4.5	3.5	2.9	2.5	2.2	2.0
150		39.0	14.8	9.2	6.7	5.3	4.4	3.8	3.3	2.9
200		51.9	19.7	12.2	8.9	7.1	5.9	5.0	4.4	3.9
250		64.9	24.6	15.3	11.2	8.8	7.3	6.3	5.5	4.9
300		77.9	29.5	18.4	13.4	10.6	8.8	7.5	6.6	5.9
350		90.9	34.4	21.4	15.6	12.3	10.2	8.8	7.7	6.9
400		103.9	39.4	24.5	17.8	14.1	11.7	10.0	8.8	7.8

[1]Solution of gas and condensation under pressure are not considered; hence the values are maxima.
[2]Gas volumes entering into velocity calculations are based on tubinghead pressure; atmospheric pressure is assumed to be 15 lb. per sq. in. in calculating the number of atmospheres.

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Converting these individual sections of pipe into one strong, leakproof gathering line is fast and economical with Aircowelding. This simplified technique saves up to 50% in welding time because it permits the use of smaller welds; yet when made with this time-saving Airco method, welds are physically superior to those made with slower welding processes. Add to this the appreciable gas and rod savings possible with Aircowelding and you have the reason why so many gathering lines are being Aircowelded.

For best results when welding pipe try this proved combination—Airco 99.5% pure oxygen, dissolved acetylene, high-speed No. 1 welding rod and the practical assistance of the members of our Applied Engineering Department. The nearest Airco office will gladly send additional information on request.

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Pipe for gathering lines is quickly cut and bevelled with an Airco Portable Pipe Beveling Machine. It leaves edges sharp and clean—ready for fast uninterrupted welding. Lightweight, economical, this oxyacetylene machine can be adjusted for any bevel cut. No power is needed—either the machine revolves around the pipe, or the pipe is turned by hand. Full details on request.

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Anything and Everything for **GAS WELDING or CUTTING and ARC WELDING**

RISE IN FLUID LEVEL, ETC., DUE TO RUNNING 1½-IN. EXTERNAL-UPSET TUBING IN WELL FLUID

Diameter of outer string or open hole, in.	Internal diameter of outer string or open hole, in.	Volume[1] contained in outer string or open hole		Volume[1] contained in annular space		Volume[1] in well bore when tubing is in hole (volume in annulus plus volume in tubing)		For every 100 ft. of tubing run in fluid, fluid level will be raised:	
		gal.	bbl.	gal.	bbl.	gal.	bbl.	in annular space when lower end of tubing is closed, ft.-in.	in well bore when lower end of tubing is open, ft.-in.
Tubing strings									
Non-upset									
3	2.992	36.52	0.870	21.62	0.515	32.20	0.767	68–11	1– 4
3	2.922	34.84	.829	19.94	.475	30.52	.727	74– 9	1– 5
3½	3.548	51.36	1.223	36.46	.868	47.04	1.120	40–10	0–11
4	3.958	63.92	1.522	49.02	1.167	59.60	1.419	30– 5	0– 9
Upset									
3	2.992	36.52	0.870	21.62	0.515	32.20	0.767	68–11	1– 4
3½	3.476	49.30	1.174	34.40	.819	44.98	1.071	43– 4	1– 0
4	3.958	63.92	1.522	49.02	1.167	59.60	1.419	30– 5	0– 9
Casing strings[2]									
4½	4.090	68.25	1.625	53.35	1.270	63.93	1.522	27–11	0– 8
4½	3.920	62.69	1.493	47.79	1.138	58.37	1.390	31– 2	0– 9
5	4.560	84.84	2.020	69.94	1.665	80.52	1.917	21– 4	0– 7
5	4.276	74.60	1.776	59.70	1.421	70.28	1.673	24–11	0– 8
5½	5.044	103.8	2.471	88.90	2.117	99.48	2.369	16– 9	0– 5
5½	4.670	88.98	2.119	74.08	1.764	84.66	2.016	20– 1	0– 6
6	5.524	124.5	2.964	109.6	2.610	120.2	2.862	13– 7	0– 4
6	5.240	112.0	2.667	97.10	2.312	107.7	2.564	15– 4	0– 5
6⅝	6.135	153.6	3.657	138.7	3.302	149.3	3.555	10– 9	0– 4
6⅝	5.675	131.4	3.129	116.5	2.774	127.1	3.026	12– 9	0– 4
7	6.538	174.4	4.152	159.5	3.798	170.1	4.050	9– 4	0– 3
7	5.920	143.0	3.405	128.1	3.050	138.7	3.302	11– 8	0– 4
7⅝	7.125	207.1	4.931	192.2	4.576	202.8	4.829	7– 9	0– 3
7⅝	6.625	179.1	4.624	164.2	3.910	174.8	4.162	9– 1	0– 3
8⅝	8.097	267.5	6.369	252.6	6.014	263.2	6.267	5–11	0– 2
8⅝	7.511	230.2	5.481	215.3	5.126	225.9	5.379	6–11	0– 2
9⅝	9.063	335.1	7.979	320.2	7.624	330.8	7.876	4– 8	0– 2
9⅝	8.535	297.2	7.076	282.3	6.721	292.9	6.974	5– 3	0– 2
10¾	10.192	423.8	10.090	408.9	9.736	419.5	9.988	3– 8	0– 1(+)
10¾	9.760	388.7	9.255	373.8	8.900	384.4	9.152	4– 0	0– 1(+)
11¾	11.150	507.2	12.076	492.3	11.721	502.9	11.974	3– 0	0– 1(+)
11¾	10.772	473.4	11.271	458.5	10.917	469.1	11.169	3– 3	0– 1(+)
13⅜	12.715	659.6	15.705	644.7	15.350	655.3	15.602	2– 4	0– 1(–)
13⅜	12.347	622.0	14.810	607.1	14.455	617.7	14.707	2– 5	0– 1(–)
Open hole (bit size)[3]									
2⅞	2.875	33.73	0.803	18.83	0.448	29.41	0.700	79 –2	1– 6
3⅞	3.875	61.27	1.459	46.37	1.104	56.95	1.356	32– 2	0 –9
4¼	4.250	73.70	1.755	58.80	1.400	69.38	1.652	25– 4	0– 8
4¾	4.750	92.06	2.192	77.16	1.837	87.74	2.089	19– 4	0– 6
5⅝	5.625	131.4	3.129	116.5	2.774	127.1	3.026	12– 9	0– 4
6	6.000	146.9	3.498	132.0	3.143	142.6	3.395	11– 3	0– 4
6⅛	6.125	153.1	3.645	138.2	3.290	148.8	3.543	10– 9	0– 4
6½	6.500	172.4	4.105	157.5	3.750	168.1	4.002	9– 6	0– 3
6¾	6.750	185.9	4.426	171.0	4.071	181.6	4.324	8– 9	0– 3
7	7.000	199.9	4.760	185.0	4.405	195.6	4.657	8– 1	0– 3
7½[4]	7.500	229.5	5.464	214.6	5.110	225.2	5.362	6–11	0– 2
7¾[4]	7.750	245.1	5.836	230.2	5.481	240.8	5.733	6– 6	0– 2
8½[4]	8.500	294.8	7.019	279.9	6.664	290.5	6.917	5– 4	0– 2
9¾[4]	9.750	387.9	9.236	373.0	8.881	383.6	9.133	4– 0	0– 1(+)
10⅝	10.625	460.6	10.967	445.7	10.612	456.3	10.864	3– 4	0– 1(+)

The 1½-in. external-upset tubing has a calculated weight of 2.89 lb. per ft. (including a coupling spaced every 20 ft.). The volume displaced by 100 ft. of tubing and 5 couplings: (1) by the steel itself (with lower end of tubing open), 0.4416 gal. or 0.01051 bbl.; (2) by the pipe (with lower end of tubing closed), 14.90 gal. or 0.3548 bbl. The volume contained within 100 ft. of the tubing is 10.58 gal. or 0.2518 bbl.

[1]All volume figures are based on 100 ft. of depth; multiply to convert other depths or lengths. For example, if the depth or length is 5196 ft., multiply by 51.96.

[2]Only maximum and minimum weights of pipe are shown for each casing size.

[3]Variation in diameter of open hole due to caving, etc., is disregarded.

[4]This diameter is an average of the two bit sizes ⅛ in. larger and smaller, respectively.

Table suggested by George B. Rice, Butler & Horne Drilling Co., Dallas, Texas.

"THIS REEL OF TIGER BRAND SET A NEW RECORD"

A Tiger Brand Wire Line Engineer reports to his boss . . .

Drove out to the McGordon location this morning, talked to the boys awhile and started to look at a big reel of American Tiger Brand they had out there.

The Superintendent drove up about that time and walked over, laid his hand on the reel and said, "Here's the best wire line we've ever had—this reel of Tiger Brand set a new record. Have yet to hear of another line in the field that can touch it in ton-mileage."

You don't have to stop and figure out why this outfit will use only American Tiger Brand Wire Lines!

Bill

YOU can safely turn your wire line problems over to an American Tiger Brand Wire Line Engineer. These men spend their time where lines are being used — they know what punishment they have to take, and what you can do about stretching your wire line dollar. They know wire lines—and they know their job. When you need help, call one of them. You can rest assured that you'll get the most practical recommendations—and in a hurry, too!

American Tiger Brand Wire Lines are made in all constructions and grades, and are quickly available throughout the oil fields. Write us for details, and ask for one of our engineers to call and check over your lines—no obligation at all.

AMERICAN
Tiger Brand
WIRE LINES
Excellay Preformed

LOOK FOR THE TIGER
Buy wire lines from the distributor who displays this sign.

AMERICAN STEEL & WIRE COMPANY
Cleveland, Chicago and New York
COLUMBIA STEEL COMPANY
San Francisco
United States Steel Export Company, New York

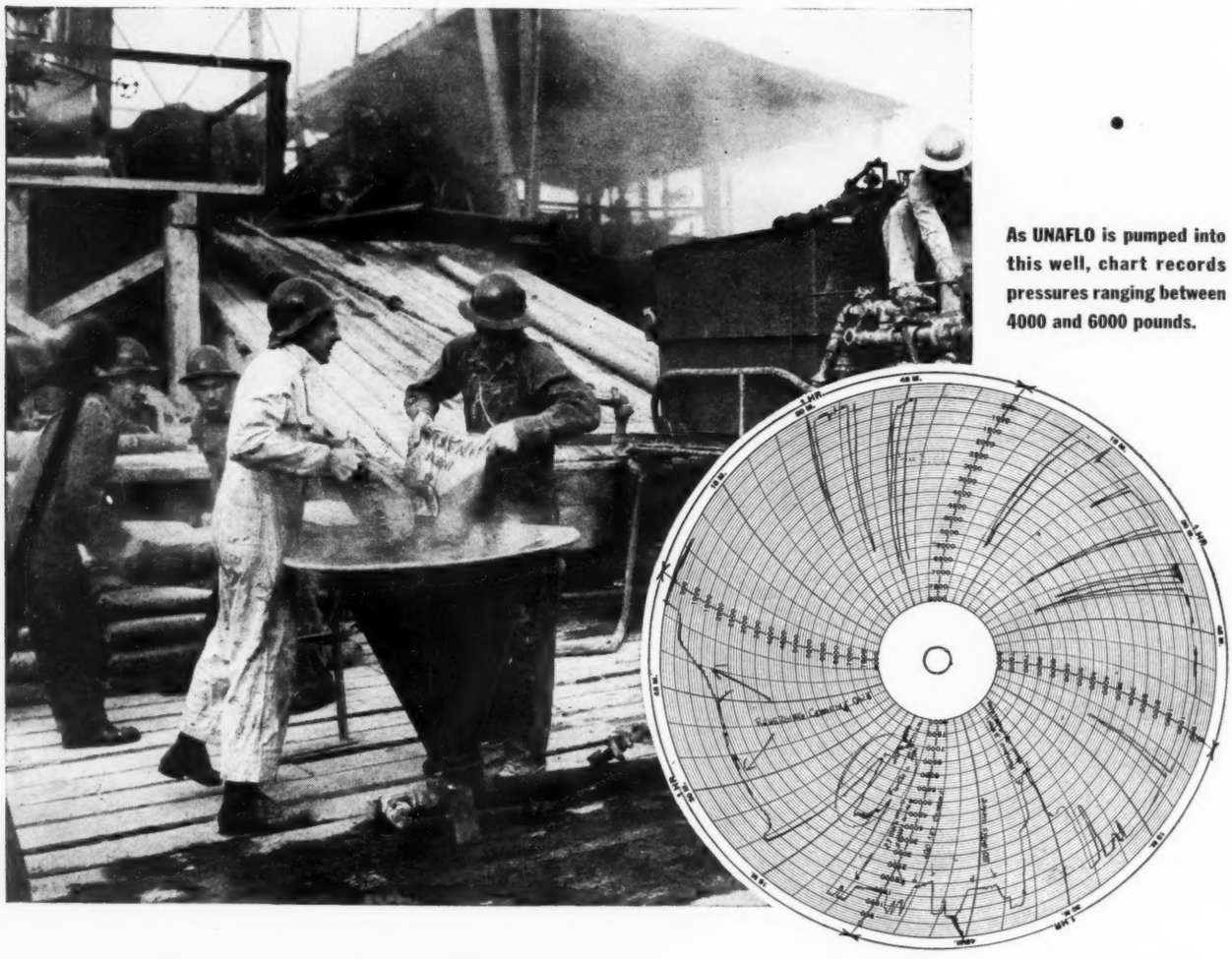
UNITED STATES STEEL

VELOCITY[1] OF FLOW, FT. PER SEC., THROUGH ANNULUS BETWEEN 1 1/2-IN. AND 4-IN. TUBING

Rate of production, bbl. per day	Gas-oil ratio, cu. ft. per bbl.	Tubing pressure[2] at casinghead, lb. per sq. in. gauge								
		0	25	50	75	100	125	150	175	200
50	300	2.7	1.0	0.7	0.5	0.4	0.3	0.3	0.3	0.2
100		5.4	2.1	1.3	1.0	0.8	0.7	0.6	0.5	0.5
150		8.1	3.1	2.0	1.5	1.2	1.0	0.9	0.8	0.7
200		10.8	4.2	2.6	2.0	1.6	1.3	1.2	1.0	0.9
250		13.4	5.2	3.3	2.4	2.0	1.7	1.4	1.3	1.2
300		16.1	6.2	4.0	2.9	2.4	2.0	1.7	1.5	1.4
350		18.8	7.3	4.6	3.4	2.8	2.3	2.0	1.8	1.6
400		21.5	8.3	5.3	3.9	3.1	2.7	2.3	2.1	1.9
50	400	3.6	1.4	0.9	0.6	0.5	0.4	0.4	0.3	0.3
100		7.1	2.7	1.7	1.3	1.0	0.9	0.7	0.7	0.6
150		10.7	4.1	2.6	1.9	1.5	1.3	1.1	1.0	0.9
200		14.3	5.5	3.4	2.5	2.0	1.7	1.5	1.3	1.2
250		17.8	6.8	4.3	3.2	2.5	2.1	1.8	1.6	1.5
300		21.4	8.2	5.2	3.8	3.1	2.6	2.2	2.0	1.8
350		25.0	10.0	6.0	4.5	3.6	3.1	2.6	2.3	2.1
400		28.6	11.0	6.9	5.1	4.1	3.4	3.0	2.6	2.4
50	500	4.4	1.7	1.1	0.8	0.6	0.5	0.4	0.4	0.4
100		8.9	3.4	2.1	1.6	1.2	1.0	0.9	0.8	0.7
150		13.3	5.1	3.2	2.3	1.8	1.6	1.3	1.2	1.1
200		17.8	6.8	4.3	3.1	2.4	2.1	1.8	1.6	1.4
250		22.2	8.5	5.3	3.9	3.0	2.6	2.2	2.0	1.8
300		26.7	10.2	6.4	4.7	3.6	3.1	2.7	2.4	2.1
350		31.1	11.9	7.5	5.5	4.2	3.6	3.1	2.8	2.5
400		35.6	13.6	8.5	6.3	4.8	4.2	3.6	3.2	2.9
50	600	5.3	2.0	1.3	0.9	0.7	0.6	0.5	0.5	0.4
100		10.7	4.0	2.5	1.9	1.5	1.2	1.1	0.9	0.8
150		16.0	6.1	3.8	2.8	2.2	1.8	1.6	1.4	1.3
200		21.3	8.1	5.1	3.7	3.0	2.5	2.1	1.9	1.7
250		26.6	10.1	6.3	4.6	3.7	3.1	2.6	2.3	2.1
300		32.0	12.2	7.6	5.6	4.4	3.7	3.2	2.8	2.5
350		37.3	14.2	8.9	6.5	5.2	4.3	3.7	3.3	2.9
400		42.6	16.2	10.1	7.4	5.9	4.9	4.2	3.7	3.3
50	700	6.2	2.4	1.5	1.1	0.9	0.7	0.6	0.5	0.5
100		12.4	4.7	2.9	2.2	1.7	1.4	1.2	1.1	1.0
150		18.6	7.1	4.4	3.2	2.6	2.1	1.8	1.6	1.4
200		24.8	9.4	5.9	4.3	3.4	2.8	2.4	2.1	1.9
250		31.0	11.8	7.4	5.4	4.3	3.5	3.0	2.7	2.4
300		37.3	14.2	8.8	6.5	5.1	4.3	3.7	3.2	2.9
350		43.4	16.5	10.3	7.5	6.0	5.0	4.3	3.8	3.4
400		50.0	18.9	11.8	8.6	6.8	5.7	4.9	4.3	3.8
50	800	7.1	2.7	1.7	1.2	1.0	0.8	0.7	0.6	0.5
100		14.2	5.4	3.3	2.4	1.9	1.6	1.4	1.2	1.1
150		21.3	8.1	5.0	3.7	2.9	2.4	2.1	1.8	1.6
200		28.4	10.8	6.7	4.9	3.9	3.2	2.8	2.4	2.2
250		35.4	13.4	8.4	6.1	4.8	4.0	3.4	3.0	2.7
300		42.5	16.1	10.0	7.3	5.8	4.8	4.1	3.6	3.2
350		50.0	18.8	11.7	8.6	6.8	5.6	4.8	4.2	3.8
400		56.7	21.5	13.4	9.8	7.7	6.4	5.5	4.8	4.3
50	900	8.0	3.0	1.9	1.4	1.1	0.9	0.8	0.7	0.6
100		15.9	6.0	3.8	2.7	2.2	1.8	1.5	1.3	1.2
150		23.9	9.1	5.6	4.1	3.2	2.7	2.3	2.0	1.8
200		31.9	12.1	7.5	5.5	4.3	3.6	3.1	2.7	2.4
250		39.8	15.1	9.4	6.8	5.4	4.5	3.8	3.4	3.0
300		47.8	18.1	11.3	8.2	6.5	5.4	4.6	4.0	3.6
350		55.8	21.1	13.1	9.6	7.6	6.3	5.4	4.7	4.2
400		63.8	24.2	15.0	11.0	8.7	7.2	6.2	5.4	4.8

[1]Solution of gas and condensation under pressure are not considered: hence the values are maxima.
[2]Gas volumes entering into velocity calculations are based on tubinghead pressure: atmospheric pressure is assumed to be 15 lb. per sq. in. in calculating the number of atmospheres.

"WE DON'T LEAD WITH OUR CHINS AT 10,000 FEET!



As UNAFLO is pumped into this well, chart records pressures ranging between 4000 and 6000 pounds.

. . . *that's why* **UNAFLO** *went into this string!"*

"YOU can never tell what'll happen to a squeeze job," reports an oil man down in Louisiana. "On this one we were working with salt water sand at 10,091 feet. 100 sacks of UNAFLO in the tubing, and bottom hole temperature 230 degrees!"

"Just look at that chart—we squeezed out 67 sacks, breaking down the formation with 5100 lbs. pressure and then pumped in the cement under pressures from four to six thousand pounds.

"Without UNAFLO there might have been serious trouble if the pumps had gone haywire. At 10,000 feet—and with temperatures well over the boiling point—we might even have lost the string of tubing. But we avoided these dangerous possibilities by using free-flowing UNAFLO."

Oil men say "Why lead with your chin?" on dangerous, difficult jobs. That's why so many operators play safe by using UNAFLO to protect their well investment. A free-flowing, hard-setting cement with a retarded set factor for safety, UNAFLO really *performs* when the going is toughest!

Try UNAFLO on your next job! For more information, see the Composite Catalog of Oil Field and Pipe Line Equipment. Universal Atlas Cement Co. (United States Steel Corp. Subsidiary), Amicable Building, Waco; Tulsa; Oklahoma City; Kansas City; Chicago; and Birmingham.

• • •

SPEED UP SURFACE CEMENTING with Atlas High Early! It saves costly rig time without sacrificing safety and efficiency. Gains strength rapidly, speeds up cementing of surface and conductor pipe. Cuts time in construction of rig foundations and cellars.

PE-U-23

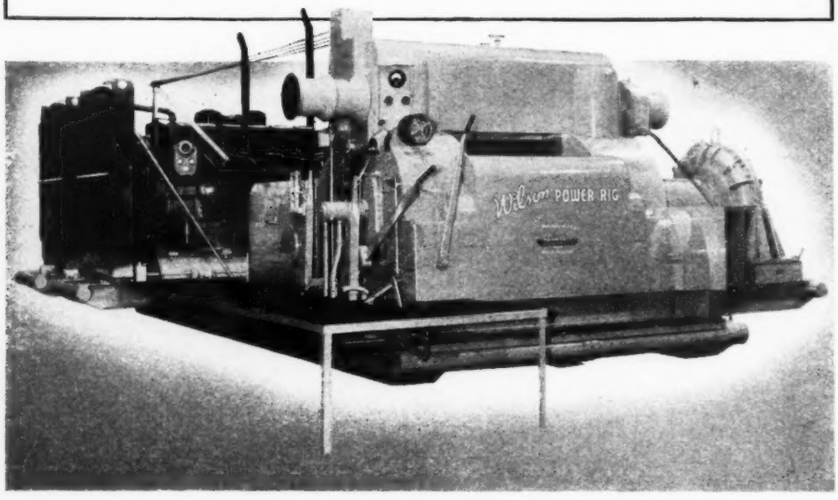
UNIVERSAL ATLAS OIL WELL CEMENTS

GRAVITY OF DRY OIL IN OIL-WATER MIXTURES, DEG. A.P.I.

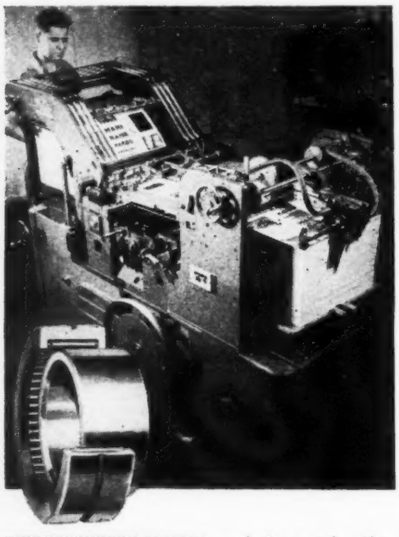
Gravity of "wet" oil deg. A.P.I.	Percent water in mixture														
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
45.0	45.4	45.9	46.4	46.8	47.3	47.8	48.4	**49.0**	49.4	**50.0**	50.6	51.2	51.8	52.4	53.1
1	.5	**46.0**	.5	.9	.4	.9	.5	.1	.6	.1	.7	.3	.9	.5	.2
.2	.7	.1	.6	**47.0**	.6	**48.0**	.6	.2	.7	.3	.9	.5	**52.0**	.7	.4
.3	.8	.2	.7	.1	.7	.2	.7	.3	.8	.4	**51.0**	.6	.1	.8	.5
.4	.9	.3	.8	.2	.8	.3	.8	.4	.9	.5	.1	.7	.3	.9	.6
45.5	**46.0**	46.4	46.9	47.4	47.9	48.4	48.9	49.5	**50.0**	50.6	51.2	51.8	52.4	**53.0**	53.7
.6	.1	.5	**47.0**	.5	**48.0**	.5	**49.0**	.6	.2	.7	.3	.9	.5	.2	.8
.7	.2	.6	.1	.6	.1	.6	.2	.7	.3	.9	.4	**52.0**	.6	.3	.9
.8	.3	.7	.2	.7	.2	.7	.3	.8	.4	**51.0**	.5	.2	.7	.4	**54.0**
.9	.4	.8	.3	.8	.3	.8	.4	.9	.5	.1	.6	.3	.8	.5	.1
46.0	46.5	46.9	47.4	47.9	48.4	48.9	49.5	**50.0**	50.6	51.2	52.8	52.4	**53.0**	53.7	54.3
.1	.6	**47.0**	.5	**48.0**	.5	**49.0**	.6	.2	.7	.3	.9	.5	.1	.8	.4
.2	.7	.2	.6	.1	.6	.2	.7	.3	.8	.4	**52.0**	.6	.2	.9	.6
.3	.8	.3	.7	.2	.8	.3	.8	.4	.9	.5	.2	.8	.3	**54.0**	.7
.4	.9	.4	.8	.3	.9	.4	.9	.5	**51.0**	.7	.3	.9	.4	.2	.8
46.5	**47.0**	47.5	47.9	48.4	**49.0**	49.5	**50.0**	50.6	51.2	51.8	52.4	**53.0**	53.6	54.3	**55.0**
.6	.1	.6	**48.0**	.5	.1	.6	.2	.7	.3	.9	.6	.1	.8	.4	.1
.7	.2	.7	.1	.6	.2	.7	.3	.8	.4	**52.0**	.7	.2	.9	.6	.3
.8	.3	.8	.2	.8	.3	.8	.4	.9	.5	.1	.8	.3	**54.0**	.7	.4
.9	.4	.9	.3	.9	.4	.9	.5	**51.0**	.6	.2	.9	.4	.1	.8	.5
47.0	47.5	**48.0**	48.5	**49.0**	49.5	**50.0**	50.6	51.2	51.7	52.3	**53.0**	53.6	54.3	54.9	55.6
.1	.6	.1	.6	.1	.6	.2	.7	.3	.8	.4	.1	.8	.4	**55.0**	.8
.2	.7	.2	.7	.2	.7	.3	.8	.4	.9	.6	.2	.9	.5	.2	.9
.3	.8	.3	.8	.3	.8	.4	.9	.5	**52.0**	.7	.3	**54.0**	.6	.3	**56.0**
.4	.9	.4	.9	.4	.9	.5	**51.0**	.6	.2	.8	.4	.1	.7	.4	.2
47.5	**48.0**	48.5	**49.0**	49.5	**50.0**	50.6	51.1	51.7	52.3	52.9	53.6	54.2	54.9	55.6	56.3
.6	.1	.6	.1	.6	.2	.7	.2	.8	.4	**53.0**	.7	.3	**55.0**	.7	.4
.7	.2	.7	.2	.7	.3	.8	.4	.9	.5	.2	.8	.4	.2	.8	.5
.8	.3	.8	.3	.8	.4	.9	.5	**52.0**	.6	.3	**54.0**	.5	.3	**56.0**	.6
.9	.4	.9	.4	.9	.5	**51.0**	.6	.2	.7	.4	.1	.6	.4	.1	.8
48.0	48.5	**49.0**	49.5	**50.0**	50.6	51.1	51.7	52.3	52.9	53.5	54.2	54.8	55.5	56.2	56.9
.1	.6	.1	.6	.2	.7	.3	.8	.4	**53.0**	.6	.3	**55.0**	.6	.3	**57.0**
.2	.7	.2	.7	.3	.8	.4	**52.0**	.5	.1	.7	.4	.1	.8	.4	.1
.3	.8	.3	.8	.4	.9	.5	.1	.7	.2	.8	.5	.2	.9	.6	.2
.4	.9	.4	.9	.5	**51.0**	.6	.2	.8	.4	**54.0**	.6	.3	**56.0**	.7	.4
48.5	**49.0**	49.5	**50.0**	50.6	51.1	51.7	52.3	52.9	53.5	54.1	54.8	55.4	56.1	56.8	57.6
.6	.1	.6	.2	.7	.3	.8	.4	**53.0**	.7	.2	.9	.6	.2	**57.0**	.8
.7	.2	.7	.3	.8	.4	.9	.5	.1	.8	.4	**55.0**	.7	.4	.1	.9
.8	.3	.8	.4	.9	.5	**52.0**	.6	.2	.9	.5	.2	.8	.5	.2	**58.0**
.9	.4	.9	.5	**51.0**	.6	.1	.7	.3	**54.0**	.6	.3	**56.0**	.6	.3	.1
49.0	49.5	**50.0**	50.6	51.1	51.7	52.2	52.8	53.4	54.1	54.7	55.4	56.1	56.8	57.5	58.2
.1	.6	.1	.7	.2	.8	.4	.9	.5	.2	.8	.6	.2	.9	.7	.4
.2	.7	.2	.8	.3	.9	.5	**53.0**	.6	.3	.9	.7	.4	**57.0**	.8	.5
.3	.8	.3	.9	.4	**52.0**	.6	.2	.7	.4	**55.0**	.8	.5	.1	.9	.6
.4	.9	.4	**51.0**	.5	.1	.7	.3	.9	.5	.1	.9	.6	.2	**58.0**	.7
49.5	**50.0**	50.5	51.1	51.6	52.2	52.8	53.4	**54.0**	54.6	55.3	**56.0**	56.7	57.4	58.1	58.9
.6	.1	.6	.2	.7	.3	.9	.5	.1	.7	.4	.1	.8	.5	.2	**59.0**
.7	.2	.7	.3	.8	.4	**53.0**	.6	.2	.8	.5	.2	.9	.6	.3	.1
.8	.3	.8	.4	.9	.5	.1	.7	.3	.9	.6	.3	**57.0**	.7	.4	.2
.9	.4	.9	.5	**52.0**	.6	.2	.8	.4	**55.0**	.7	.4	.1	.8	.5	3

IN THE NEWS

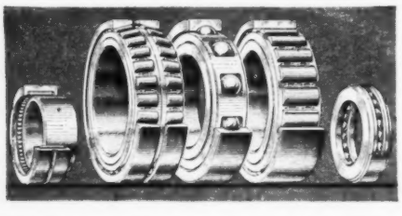
WITH BANTAM BEARINGS



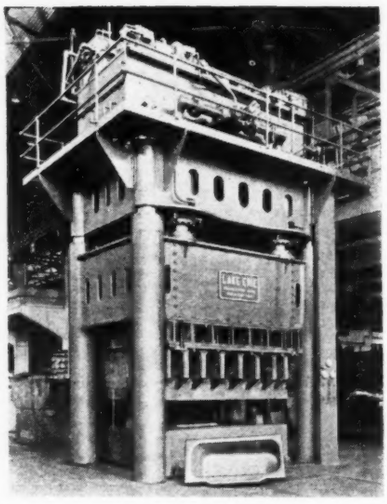
ECONOMICAL DRILLING of wells of any required depth is made possible by the modern design of the power rigs built by Wilson Manufacturing Co., Inc. Typical of the drilling potentialities of the Wilson line are the Giant, Atlas, and Titan Models, with rated capacities of 6,000, 8,000, and 12,000 feet, using 4½" drill pipe. Bantam Bearings are functioning successfully and economically in clutches on the drum shafts of these models. Other Bantam Bearings are serving the oil industry in pumpers, rotaries, swivels, and crown and traveling blocks.



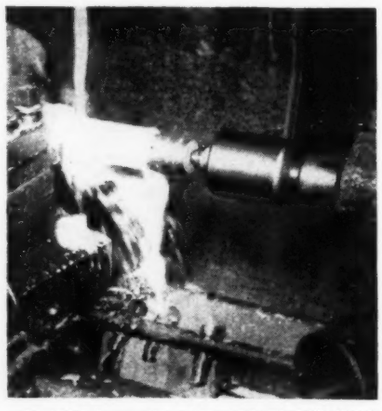
NEW PRODUCTION RECORDS are being set by the Kelly Clipper Printing Presses manufactured by American Type Founders. Bantam Quill Bearings are used on planetary gear and crosshead crank pin of the bed motion of these up-to-the-minute presses. Bantam also serves the builders and users of printing presses with other types of bearings specially designed for high-speed rotation.



EVERY MAJOR TYPE OF ANTI-FRICTION BEARING is included in Bantam's line—straight roller, tapered roller, needle, and ball. Bantam engineers, with their broad background of experience in bearing design and application, recommend the type that best suits *your* needs—or design special bearings to meet unusual conditions. If you have a difficult bearing problem, TURN TO BANTAM.



THIS 1700-TON FORMING PRESS is powered by two variable displacement pumps manufactured by The Oilgear Company and equipped with large-size Bantam Radial Roller Bearings, 12.5984" and 16.5354" O.D. Here is a typical instance of the ways in which heavy-duty Bantam Bearings are serving industry in exceptionally severe applications.



HIGH CAPACITY IN A SMALL SPACE is secured in the live centers built by Motor Tool Manufacturing Company through the use of Bantam Quill Bearings. For additional information on this compact anti-friction bearing, write for Bulletin P-104.

BANTAM BEARINGS

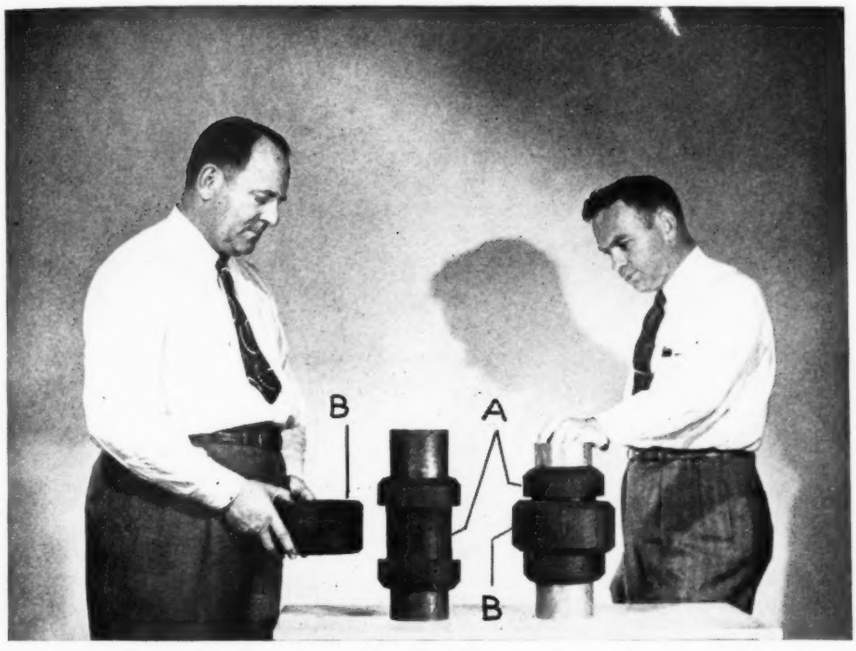
STRAIGHT ROLLER · TAPERED ROLLER · NEEDLE · BALL

BANTAM BEARINGS CORPORATION • SOUTH BEND • INDIANA

MACHINERY and EQUIPMENT

Drill-Pipe Bearing

THE Grizzly "Hug-Tite" Drill Pipe Bearing, for casing and open-hole drilling, is a new product recently announced by E. M. Smith Company, Los Angeles, California.



Walter Smith, inventor (left), demonstrating where Grizzly "Hug-Tite" bearing fits on base installed on drill pipe

Shown here with the inventor, Walter Smith, general manager of the above company, this product is made entirely of rubber of special formula and consists of two parts. In the illustration is shown: (a) the "Hug-Tite" base, made in one solid piece and shaped like a spool, with flanges at each end; and (b) the free-spinning "Hug-Tite" bearing that fits over the base between the flanges. The clearance between the bearing and the base, both radially and endwise, is such as to permit the bearing to turn freely without friction, and is lubricated by the mud circulating in the hole, which creates an extremely smooth, slippery surface, eliminating practically all friction and wear on these parts.

In service, when the bearing (b) comes in contact with the formation or casing it stops turning, whereas the drill pipe and base (a) continue to rotate, thus actually functioning as a positive roller bearing, eliminating torque and stress on the pipe, and completely stabilizing the entire drilling string, according to the manufacturer. As the drill pipe is protected against all contact with the formation or casing by the oversize bearing, the drill pipe, tool joints, and casing are completely protected at all times and wear on these parts is reduced to a minimum. The rubber-to-rubber contact between the bearing and base, together with the free-spinning, mud-lubricated clearance between these parts, enables the bearing to withstand any contact with the formation or casing with little or no wear, it is stated.

Grizzly "Hug-Tite" drill-pipe bearings, protectors and stabilizers, and installation equipment are fully covered by patent applications. Detailed information may be obtained by writing direct to the manufacturer for Bulletin No. 22 OF.

Brown Circular Chart Potentiometer Pyrometer

THE Brown Instrument Company announces the development of a circular chart potentiometer. This is a new type of self-balancing instrument for indicating and recording temperature. It employs the null-point

potentiometer measuring circuit, but its balancing system is entirely new, the manufacturer states.

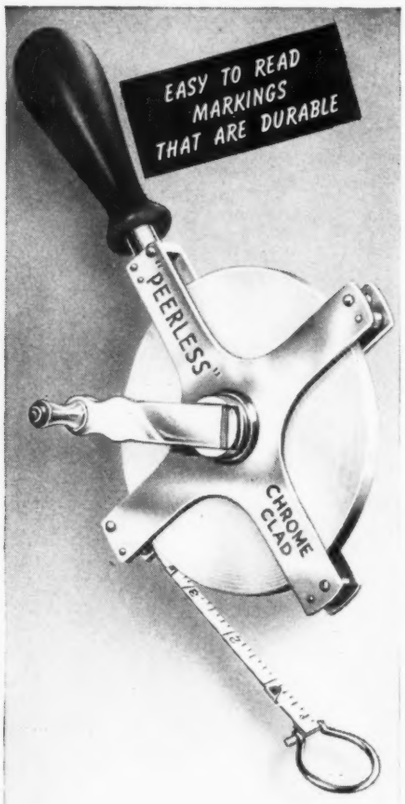
The balancing system is continuous. It has no galvanometer. All live parts are enclosed. All amplifier components are oversize. Sensitivity may be adjusted for correct operation on any standard pyrometer range, thus making all amplifiers interchangeable.

The balancing motor is a brushless, reversible induction motor with built-in gear reduction, and is totally enclosed.

The rectangular case is of sturdy construction with rigid die-cast door. Special baked, durable black enamel finish resists corrosion in moist, salt, or acid atmospheres. Universal mounting permits flush or front-of-board mounting.

The new Brown Circular Chart Potentiometer combines sensitivity, speed of response, accuracy, simplicity, and ruggedness, the makers assert.

These and many other features are fully described in Catalog No. 1501. A copy will be sent to those requesting it. Address The Brown Instrument Company, Wayne and Roberts Avenues, Philadelphia, Pennsylvania.



"PEERLESS" CHROME CLAD

If you're interested in a steel tape for tank strapping, be sure to see the Lufkin "Peerless" Chrome Clad. You'll find it perfect for the job. Jet black markings are easy to read against the satin chrome surface that won't rust, crack, chip or peel. Frame is extra sturdy and winding mechanism extra smooth. See your supply house and write for free general Catalog.

LUFKIN

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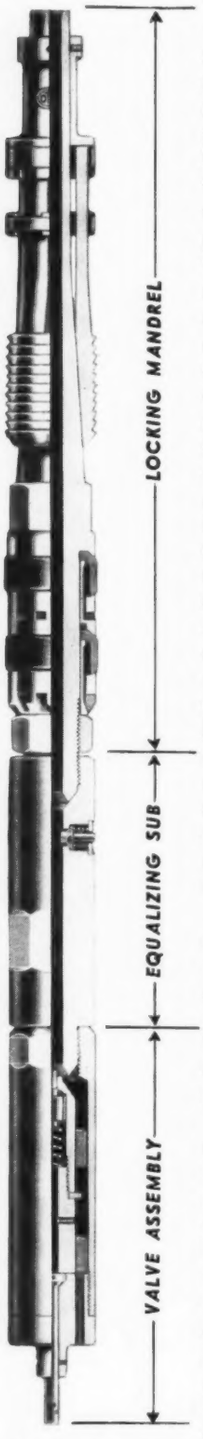
TAPES · RULES · PRECISION TOOLS

Otis Equalizing Sub

THE purpose of the new Otis Equalizing Sub, manufactured by Otis Pressure Control, Inc., Dallas, Texas, is to provide a safe and fast means to equalize pressures across Otis removable bottom-hole safety valves, regulators, and chokes, particularly when well conditions, such as unbalanced tubing and casing pressures, casing packers, etc., prohibit equalizing by connecting the tubing and casing at the surface. It is absolutely necessary that pressures across all Otis subsurface controls be fully equalized before they can be pulled. This new tool has proved to be the safest and simplest of all equalizing devices for this operation, according to the manufacturer.

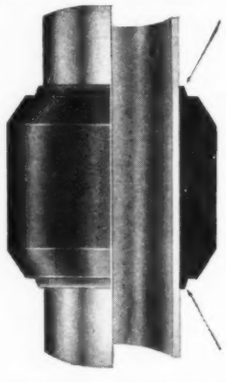


This device is merely a bypass valve built in the side of a special sub made to go between the mandrel assembly and the main valve assembly of Otis subsurface controls. Consequently, the position of the bypass is below the tubing sealing cups and above the main control valve. The bypass consists of a ground seat built into the side of the sub in which a valve and stem fit. A small spring acts to hold the valve closed while an orifice plate pressed in the sub holds the assembly in place. The valve has a rounded nose that protrudes into the bore of the sub approximately ⅛ in. This protruding nose in no manner interferes with the normal operation of the choke, regulator, or safety valve, but does provide a means for the operator to open the bypass when desired. Under normal operations the valve is held closed by the differential pressure across the subsurface control and at this time serves no purpose.

To open the bypass valve a special equalizing tool is run in the hole on the conventional steel line, jars, and stem. This device has a long prong with a tapered end extending from the body of the tool. This prong passes through the bore of the mandrel assembly and sub and forces the protruding valve nose back, opening the bypass. One stroke of the jars is usually sufficient to drive the prong past the valve to lock it open. The bypass valve is designed so the effective opening through the ground seat is larger than the effective opening in the orifice plate. This feature reduces the differential across the ground seat and minimizes the cutting action on these parts. Care also has been taken to select an orifice small enough that the velocity of the flow through the bypass cannot possibly blow the tools up the hole regardless of the pressure encountered. As soon as the prong is pulled out of the sub the small spring snaps the valve closed making it ready for normal operation again.

Lip Protectors to Overcome Ringing of Drill Pipe

OXIDATION or erosion of drill pipe that causes "ringing" has been effectively prevented by use of rubber protectors with extended lips at both ends, according to Patterson-



Ballagh engineers, who have developed this new design.

Drillers in some localities have observed an erosive action at abrupt corners of tool joints and where protectors fit the pipe. This is caused by settling of chemicals in the mud and cavitation sometimes occurs due to the swirling action of the circulation.

The use of streamlined tool joints

has helped overcome cavitation and the improved designing of protectors with lip is in line with the movement to streamline the entire string.

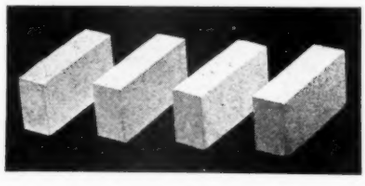
According to Patterson-Ballagh engineers, the use of lips prevents any swirling in the corners because the lips eliminate abrupt ells and the swirling occurs on the rubber that effectively resists abrasion.

Perfect streamlining of protectors is impracticable but by adding lips a streamline effect is provided. These lips are long enough to cover the points where erosion may possibly take place. They form a rubber wall against which the chemicals in the mud can concentrate. As the extended lips increase the area in contact with the pipe and keep the mud from getting underneath, the gripping effect is said to be greatly increased, reducing slipping action and extending the life of the protectors.

Further details may be obtained from Patterson-Ballagh Corporation, 1900 East 65th Street, Los Angeles, California.

Insulating Fire Brick By Johns-Manville

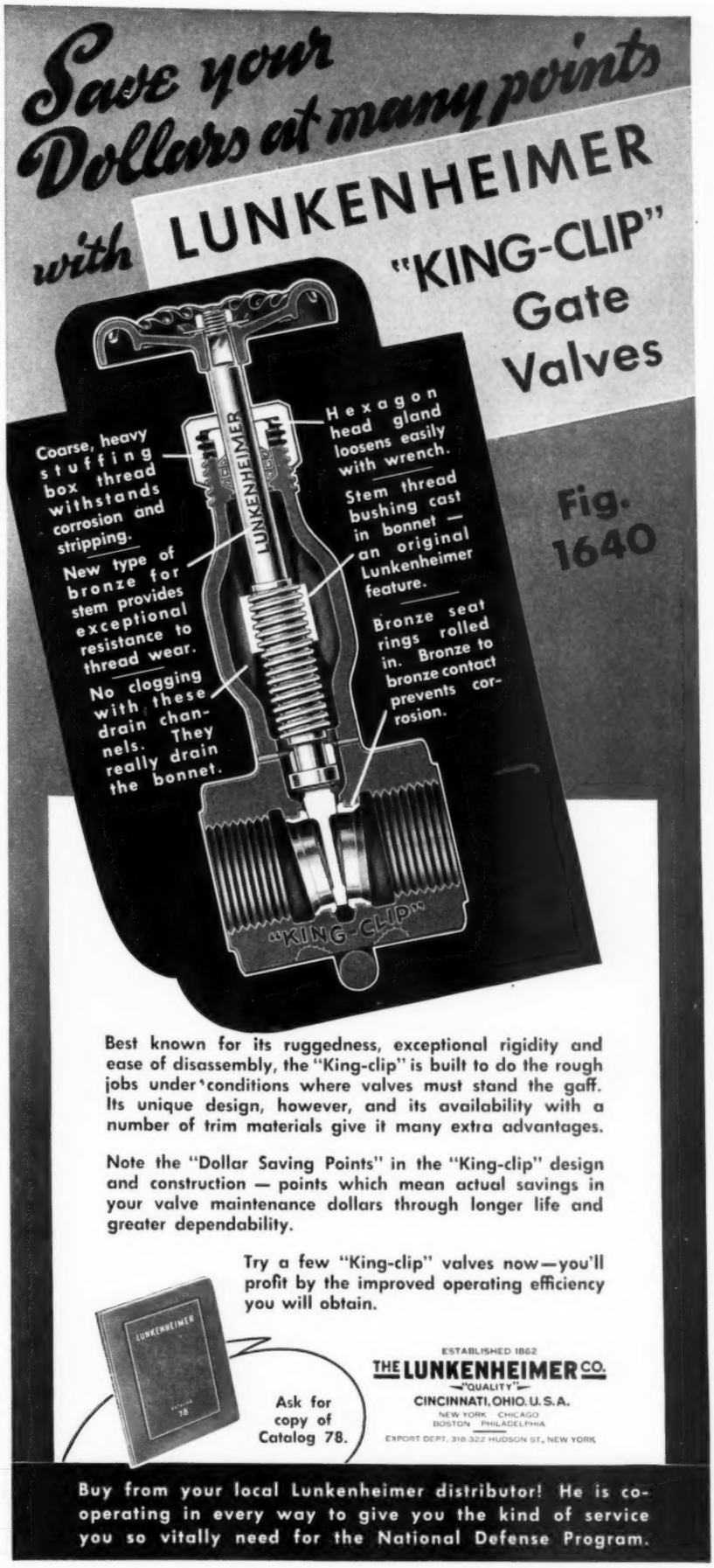
A NEW LINE of insulating fire brick for the temperature range from 1600 to 2600°F. has been announced by Johns-Manville, designed for direct exposure in a wide variety of furnaces, ovens, and other heated



equipment, except when subject to slag action or mechanical abuse. The brick are supplied in four temperature limits: JM-16, for exposed service to 1600°F. and for back-up service to 2000°F., and JM-20, JM-23, and JM-26 for exposed or back-up temperatures to 2000, 2300, and 2600°F., respectively. The new line supplements the Johns-Manville Sil-O-Cel series of back-up insulating brick for temperatures of 1600, 2000, and 2500°F.

The new insulating fire brick are produced from a plastic refractory clay and an organic filler, which, upon being burnt out during the manufacturing process, gives a uniform, controlled pore structure to each of the various types, and imparts the characteristics of light-weight, strength, and high insulating value.

Production of the new brick has been recently started at Zelienople, Pennsylvania, in Johns-Manville's newest plant.


Save your Dollars at many points with LUNKENHEIMER "KING-CLIP" Gate Valves
Fig. 1640
Coarse, heavy stuffing box thread withstands corrosion and stripping.
New type of bronze for stem provides exceptional resistance to thread wear.
No clogging with these drain channels. They really drain the bonnet.
Hexagon head gland loosens easily with wrench.
Stem thread bushing cast in bonnet — an original Lunkenheimer feature.
Bronze seat rings rolled in. Bronze to bronze contact prevents corrosion.
LUNKENHEIMER
"KING-CLIP"
Best known for its ruggedness, exceptional rigidity and ease of disassembly, the "King-clip" is built to do the rough jobs under conditions where valves must stand the gaff. Its unique design, however, and its availability with a number of trim materials give it many extra advantages.
Note the "Dollar Saving Points" in the "King-clip" design and construction — points which mean actual savings in your valve maintenance dollars through longer life and greater dependability.
Try a few "King-clip" valves now—you'll profit by the improved operating efficiency you will obtain.
LUNKENHEIMER
Ask for copy of Catalog 78.
ESTABLISHED 1862
THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
NEW YORK CHICAGO
BOSTON PHILADELPHIA
EXPORT DEPT. 318-322 HUDSON ST., NEW YORK
Buy from your local Lunkenheimer distributor! He is co-operating in every way to give you the kind of service you so vitally need for the National Defense Program.

Elastic Stop Announces Thin Hex Nuts

FOR USE on shear bolts when a high degree of the stress is lateral, and for general application to light and medium stress fastenings, an improved line of thin hex nuts is announced by Elastic Stop Nut Corporation, 2332 Vauxhall Road, Union, New Jersey.

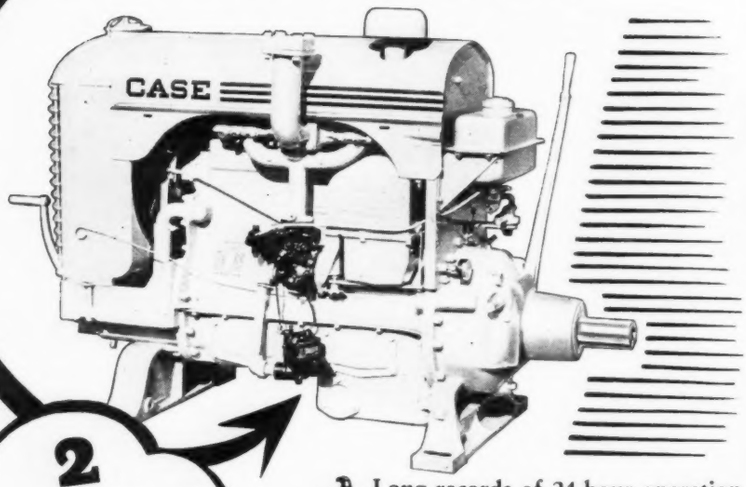
These nuts have approximately 40 percent of the strength of standard-height hex nuts and have been developed to meet the demand in virtually every industry for a self-locking fastening that offers savings in space requirements, weight, and cost, it is announced.

As in the standard-height Elastic Stop Nuts, the self-locking action is accomplished by means of a vulcanized fiber collar built into the head of the nut. This tough, bone-like material resists the entry of the bolt, thus forcing the nut outward and taking-up all thread play. The fiber, being non-metallic and of a resilient character, does not deteriorate under vibration, and so continues to hold the threads of nut and bolt in a constant pressure-contact, it is stated.

The nuts are available in steel, brass, and aluminum, in a complete range of standard sizes, both coarse and fine thread. A folder, sent upon request to the manufacturer, explains in detail the Elastic Stop self-locking principle.

Something New for Oil Pumping

Extra Endurance in All Weather



2 Brand-New Models

Long records of 24-hour operation ... two years on original rings and oil consumption still low ... three years with nothing new but plugs and fan belt ... five years and still going strong on first ring renewal ... made Case oilfield engines famous. Now there are new models built to beat those records. They have wider margins of cooling capacity to cope with hotter weather ... improved oil pumps, strainers and distribution ducts for positive lubrication under colder conditions ... more perfect protection against dust and moisture. Let distributors furnish full information. J. I. Case Co., Racine, Wis.

DISTRIBUTORS

Southwest Equipment Co.
Dallas and Kilgore, Texas

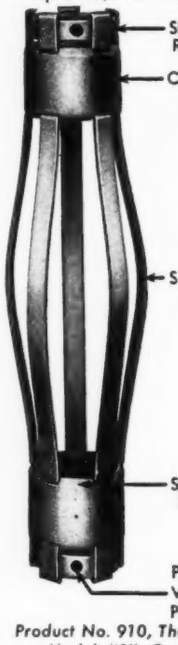
Leland Equipment Co.
Tulsa, Oklahoma

Howard Supply Co.
Los Angeles, Calif.

CASE
Oil Field Engines

Casing Centralizer

A NEW design of casing centralizer to provide an effective means of centering casing either in cased or open hole has recently been developed by Baker Oil Tools, Inc., Box 127, Vernon Station, Los Angeles, California. Known as Baker Model "B" Casing Centralizer, this tool is so constructed that the springs are always pulled through a restricted area, thus eliminating any pushing that tends to cause expansion at points where contraction is necessary. The centralizer is attached to the string of casing by merely slipping it on the pipe, positioning it at the desired point, and plug-welding two stop rings to the casing.



Product No. 910, The Baker Model "B" Casing Centralizer

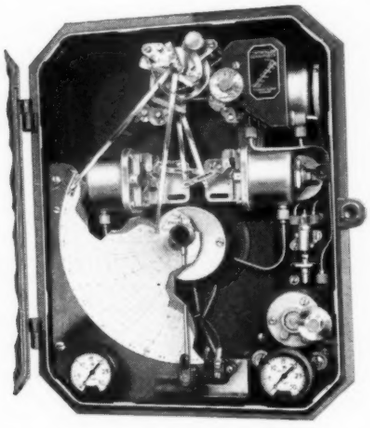
As shown in the illustration, the centralizer consists of a number of springs, two collars, and the two stop rings. The collars are placed near the ends of the springs to confine them at top and bottom and to maintain their circumferential position. The springs are not attached to the collars but are made with an offset where they pass through the collars and are held in proper position by means of spacer lugs projecting from the top and bottom of each collar, the ends of the lugs being turned down to hold the springs securely in place. Elongation of the springs is limited by the stop rings to give a specified compressed diameter to the centralizer when the collars contact the stop rings. The ends of each spring are forged hooks that fit over the outer edges of the stop

rings and give a specified maximum diameter to the centralizer.

The only parts actually attached to the casing are the stop rings, which are welded to the pipe by means of plug welds at four points. The springs and collars are free to turn as a unit, and when running casing equipped with this centralizer there are no strains set up when the casing is turned nor has the centralizer any tendency to revolve as it goes down the hole. The design also results in the centralizer always being pulled through other strings of casing by a stop ring and not being pushed through. This pulling action permits the centralizer to contract readily when going through a restriction instead of having to overcome a tendency to expand as would be the case if its action resulted from it being pushed against the restriction obstructing its passage.

Direct-Set Ratio Controller

A HIGHLY adaptable, easily convertible instrument for applications where a temperature, pressure, rate of flow, or liquid level must be controlled in a desired ratio or differential to another related variable is now offered by the Taylor Instrument Companies, Rochester, New York.



With the new direct-setting Taylor Ratio Controller the ratio is changed by a simple screwdriver adjustment directly on a calibrated dial throughout the range of 0:1 to 3:1, direct or inverse. With this new instrument it is unnecessary to disturb the processing or remove the chart plate while making ratio adjustments.

The Taylor Ratio Controller has two measuring systems, one the adjusting system that indicates or records only; and the other, the controlling system, which may either indicate or record. The adjusting system resets the control point of the controlling system through a linkage arrangement according to a predetermined ratio. The action of the controlling system is the same as the 120R Series Fulscopes and may be used as a single-duty bi-recording controller when the ratio setting is zero.

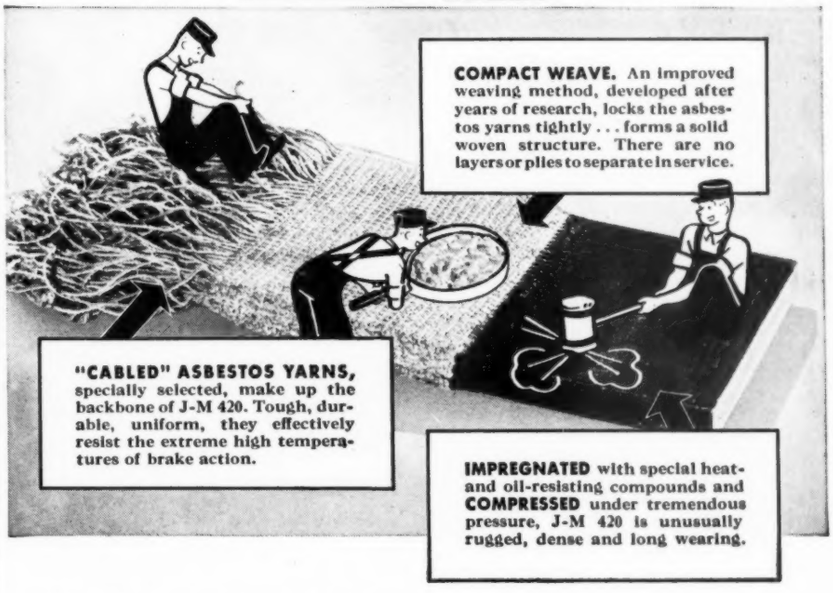
Both indicating and recording models of the ratio controller are available with all the features of the 120R Series Fulscope.

Write for Bulletin No. 98158.

Protective Insoles for Boots and Shoes

PROTECTIVE insoles for wearing inside rubber boots and shoes have new comfort because of a new type of construction. Two thin protective layers of a special plastic material assure puncture-resistance and make these insoles so flexible the sole may be rolled in a circle. A woven, glove-fitting cover gives cushion-comfort. They are non-absorbent and weigh but two ounces. The waterproof plastic material and woven cover permits them to be washed frequently without damage. Available in sizes from 6 to 11 from E. D. Bullard Company, 275 Eighth Street, San Francisco, California.

What makes J-M 420 a Better Rotary Lining?


COMPACT WEAVE. An improved weaving method, developed after years of research, locks the asbestos yarns tightly . . . forms a solid woven structure. There are no layers or plies to separate in service.
"CABLED" ASBESTOS YARNS, specially selected, make up the backbone of J-M 420. Tough, durable, uniform, they effectively resist the extreme high temperatures of brake action.
IMPREGNATED with special heat- and oil-resisting compounds and COMPRESSED under tremendous pressure, J-M 420 is unusually rugged, dense and long wearing.

WHEREVER used, J-M 420 Rotary Lining delivers these four important advantages:

Unusually even feed-off, giving better control of drilling . . .

Higher braking efficiency, even at extreme temperatures caused by heavy loads . . .

Longer life, under any conditions . . .

Less rim scoring, making drums last longer . . .

In every major oil field in the country, J-M 420 Lining is helping keep braking efficiency high, operating costs low. Owners, operators, drilling crews all agree, "You can't beat it for continued dependable performance on the job!" A tryout on your own rigs will convince you. For details, write for brochure FM-10A. Johns-Manville, 22 East 40th Street, New York, N. Y.

Johns-Manville 420 ROTARY LINING

"Texcor", Deep Oil-Well Cement

PARALLELING the continuing trend toward deep drilling, the Lone Star Cement Corporation has announced the introduction of "Texcor" Deep Oil-Well Cement. This cement was specially developed for use in the deepest wells at the highest temperatures encountered today or likely to be encountered at depths of even 15,000 ft. or greater.

Mixed with 40 percent water, "Texcor" is pumpable in excess of 8 hours at 200°F., thus providing an increased factor of safety in oil-well cementing, and at the same time producing strengths in excess of 5000 lb. per sq. in. in 24 hours and more than 6000 lb. in 48 hours, the manufacturer states.

"Texcor" produces intimate mixtures of cement and water, resulting in free-flowing slurries, low pump pressures, and a great margin of safety in the cementing operation, it is stated. Less mixing water is required, permitting the use of heavier, denser slurries with normal pump pressures, the makers assert. This degree of pumpability with low water content is a further factor in producing hardened cement that is dense and strong, the manufacturer points out.

An additional feature is the fact that during mixing, a "Texcor" slurry automatically indicates the presence of excess mixing water by the appearance of excessive surface bubbles in the slurry tub—introducing a safeguard against the use of too much mixing water. In developing "Texcor," the Lone Star oil-well cement research laboratory also had in mind the special problems of squeeze jobs where longer pumpability, low initial viscosity, and maximum density make possible satisfactory results even under the most difficult operating conditions, it is said.

For further details, address Lone Star Cement Corporation at either Dallas or Houston, Texas.

THE NEW GRIZZLY "HUG-TITE" DRILL PIPE BEARING-PROTECTOR

LESS TOOL JOINT WEAR

LESS KINKING OF DRILL PIPE

MINIMUM TORQUE STRESS

LESS DANGER OF TWIST OFFS

REDUCED FUEL CONSUMPTION

LESS WEAR AND TEAR ON MACHINERY

HIGHER EFFICIENCY AND ECONOMY

The free-spinning Bearing "B" of this new type protector stops turning when it comes in contact with the formation or casing, permitting the Base "A" and drill pipe to continue rotating; thus functioning as a positive roller bearing and reducing torque and stress to minimum while assuring better stabilization of the drilling string and protecting drill pipe, tool joints and casing against all metal to metal contact. Rubber-to-rubber contact between the Bearing and Base, together with the free-spinning mud-lubricated clearance between these parts, enables the Bearing to withstand contact with the formation or casing with little or no wear. Both Bearing and Base hydraulically installed by unique and specially designed equipment, insuring a tighter grip on pipe and the use of a stronger and tougher rubber, both contributing to better protection and longer wear. Ask your supply dealer, or write for Bulletin No. 22-OF.

E. M. SMITH COMPANY

600-650 South Clarence Street, Los Angeles, California, U. S. A.

Complete Stocks Maintained in Our Warehouses At:

407 Velasco Street, Houston, Texas — 1008 S. E. 29th St., Oklahoma City, Okla.
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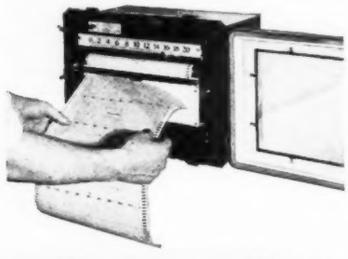
Export Office: Continental Emsco Co., 30 Rockefeller Plaza, New York City

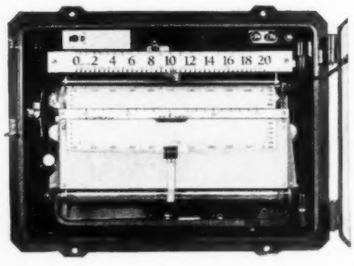
Distributed by Leading Supply Companies.

GRIZZLY "HUG-TITE" DRILL PIPE BEARING-PROTECTOR

Daily or Batch Strip Chart Tear-Off Feature

A NEW tear-off feature can now be supplied by C. J. Tagliabue Manufacturing Company of Brooklyn, New York, for Celectray recorders and





recorder-controllers. It consists of a tear-off bar and a re-roll with clip and tape. The clip, of a special design without springs, firmly grips the chart after a chart section has been removed.

It is asserted that this feature is particularly useful for daily records as well as a complete record of any batch or run. These short chart strips can be easily filed for ready reference.

The manufacturer points out that this feature provides a minimum of chart waste and when daily records are required a special chart can be supplied, with hour markings and with sufficient space to allow for resetting on correct time line.

"Norris Defender" Sucker Rod Couplings

ONE of the most serious problems facing the production engineer is the frequency of breaks in sucker-rod strings due to electrolysis and accompanying corrosion.

W. C. Norris, Manufacturer, Inc., Tulsa, Oklahoma, have published their Bulletin No. 30 describing in detail the new "Norris Defender" sucker rod couplings, incorporating the use of pure electro zinc in proper form to combat electrolysis and corrosion.

The results of many tests, in wells under varying conditions of electrolysis and corrosion, are incorporated in this bulletin. These tests reveal a careful analysis of the protective effect obtained by use of pure zinc in combating electrolysis and corrosion and length of increased service of sucker rods due to this protection.

"Norris Defender" sucker rod couplings are used on the sucker rod string in place of the ordinary coupling. The inexpensive zinc in this coupling is attacked first by electrolysis and corrosion, and in dissolving this zinc leaves the more expensive rods and tubing intact. Due to the greater affinity of zinc to acid, the strength of the acid or the electrolytic depositional current is dissipated before the parent metal of the more expensive equipment is attacked and corroded.

Construction of the "Norris Defender" sucker rod coupling is such that the reinforcing medium holds zinc firmly in place, preventing sluffing-off of masses of zinc as the electrolysis and corrosion eat it away, and thus protects valves and pumps, it is stated.

"Norris Defender" sucker rod couplings do not attempt to stop corrosion or electrolysis, but rather give protection to the more expensive equipment by providing an inexpensive metal to dissipate the ravages of both. They also provide cathodic protection for tubing as well as sucker rods. The zinc in these couplings may be easily replaced after deterioration. The zinc is held in place in such manner that no inconvenience is encountered in handling rods.

"Norris Defender" sucker rod couplings are available in both regular and extra long length couplings. Full information and prices are also available in Bulletin No. 30 by writing the manufacturer, W. C. Norris, Manufacturer, Inc., Tulsa, Oklahoma.

Midget Reversible Ratchet Wrenches

J. H. Williams and Company, 225 Lafayette Street, New York, New York, have recently added a Midget Pattern Reversible Ratchet to their "Supersocket" line. This tool, which has a ¼-in. square drive, is 4½ in. long. It incorporates the same patented double-tooth pawl for both "on" and "off" rotation as is used in other Williams' "Superratchet" wrenches. A convenient shift lever at the head instantly reverses the wrench action. The handle is drop-forged from high tensile carbon steel; working parts are machined from chrome-molybdenum steel and are heat-treated. The wrench is finished in chrome-plate over nickel.

PRODUCE FROM 2 HORIZONS

with an OTIS TYPE G

Removable Bottom Hole Choke

That's right—production coming up from Two Zones, independent of each other, through the same tubing is possible with an OTIS Side Door Choke.

When the choke is equipped with a perforated cup mandrel and blank bean, production may be had from upper formation. A blank mandrel and no bean will allow production from lower formation. Or it may be regulated to produce from both horizons at the same time.

This tool is most applicable for acidizing two zones independently of each other—also, to provide a means to displace the mud column to "wash in" the annulus after the packer has been set or to wash out sediments from the annulus when the packer is to be pulled.

Securely held in place by a positive locking mechanism, yet it is easily removed and changed with an ordinary steel measuring line.

Your nearest OTIS representative will gladly give you full information.

OTIS PRESSURE CONTROL, Inc.

DALLAS, TEXAS

Branches: Oklahoma City, Okla.; Houston, Texas; Hobbs, N. M.

Representatives: Otis Eastern Service, Inc., Wellsville, New York; Western Pressure Control, Inc., Los Angeles, California

Export Office: 74 Trinity Place, New York City

OTIS PRESSURE CONTROL SERVICE EQUIPMENT "Don't Kill Your Well" Call OTIS

Ratchet Type Cable Reel Jack

A NEW addition to their line of Simplex Cable Reel Jacks and other jacks has been announced by Templeton, Kenly and Company, 1020 S. Central Avenue, Chicago, Illinois.

Designated Model 3-CR, these new rugged jacks speed handling of cable reels so that cable, wire rope, barbed wire, or rope can be quickly paid out or readily rolled onto the reel.

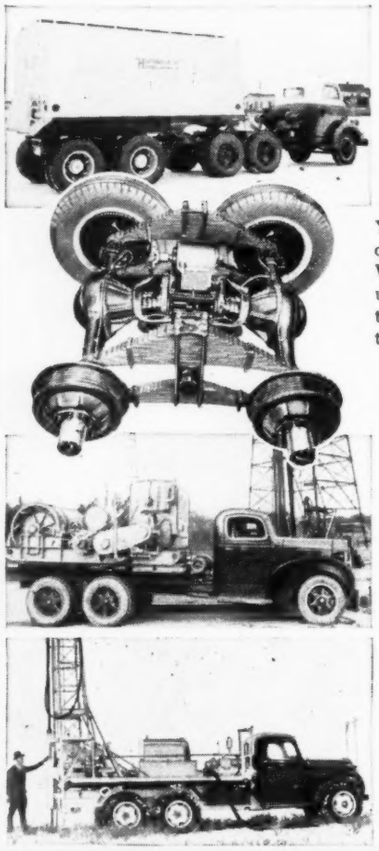
Each jack is mounted on a "T"-shaped laminated oil-treated oak base with three supporting rods for stability. A lifting hook on the head of the jack accommodates spindles to 2¼-in. diameter.

Used in pairs, one on each side of the reel, the ratchets provide for fast lifting and lowering of either loaded or empty reels. They have a capacity of 15 tons.

These jacks are ideally adapted for stringing communication lines in combat zones and for post-war communications and power line reconstruction work, it is stated.

Do You Want to Save on *Hauling Costs?*

Here's a sure way to make substantial cost reductions on your hauling. Truck users in more than a score of industries report savings as high as 40% on investment, 30% on operating costs and 35% on upkeep expense.



SAVE ON ORIGINAL COST

You save on investment since instead of buying a big, heavy-duty truck you select a smaller unit of any standard make—one priced low as a result of mass production.

ADD A THORNTON DRIVE

Your nearby Thornton distributor will quickly add a Thornton Four-Rear-Wheel Drive—a correctly-engineered unit with all necessary reinforcements that become an integral part of your truck.

HAUL DOUBLE THE PAY LOAD

You'll have a truck that will easily haul more than twice the usual load and likewise assure better traction for hill, hole or soft ground. Thornton inter-axle two-speed transmission gives speed for the highway and big gear reduction for heavy pulling.

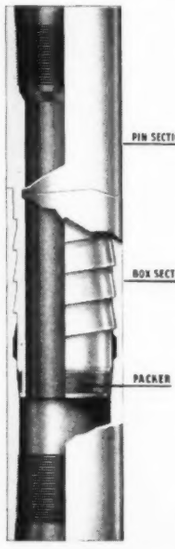
YOU SAVE IN EVERY WAY

First cost is far less than that of a conventional truck of equal capacity. Operating and upkeep costs are less. Speed and tractive effort are greater. Six-wheel braking provides greater safety. In fact, from every standpoint you'll save money and do a better job with a Thornton Drive. **Write today for complete story.**

THORNTON TANDEM CO.
8733-8779 GRINNELL AVE. DETROIT, MICH.
Manufacturers also of the THORNTON automatic-locking DIFFERENTIAL
"When you need TRACTION you need THORNTON"

Bowen Tubing Safety Joint

A NEW safety joint made especially for use in tubing strings has been developed by S. R. Bowen Company, Santa Fe Springs, California. This tool insures quick, positive release of the string should the tubing below the joint sand-up, the tubing packer stick, or other well conditions prevent removal, the manufacturer states. Installed in the string above the packer, or above the point where sanding-up is liable to occur, this safety joint can eliminate costly cutting and pulling jobs, it is asserted.



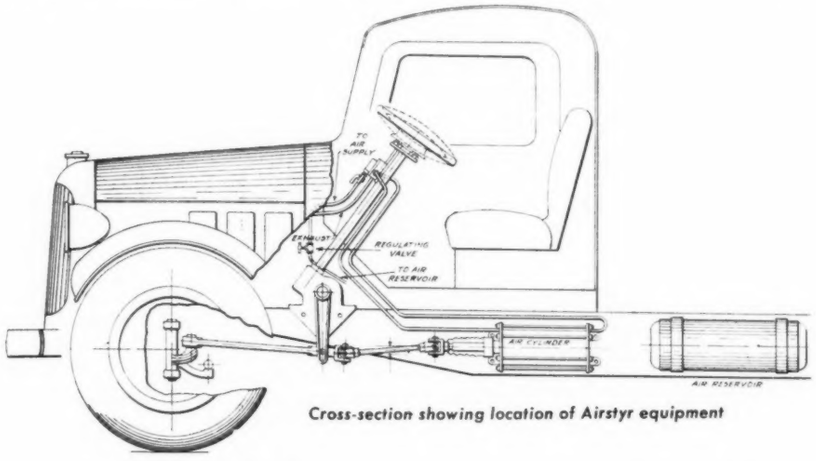
The tubing safety joint is similar in construction to the regular Bowen safety joint for drill pipe, consisting simply of a pin and a box section and packers. Standard double-box connections are provided for placing the joint in the string. Other dimensions are also the same as the tubing sizes with which the joints are used: outside diameter is no greater than the tubing couplings, and full opening on the inside is provided so that any tool able to enter the tubing can be safely run through the joint. Fluid passage is not interfered with in any way, and the packers seal-off against all leakage inside or outside the string.

Definite mechanical actions are required to break the tubing safety joint. Twisting or pulling strains (frequently necessary when setting packers, using the tubing as a fishing string, or performing other bottom-hole work) will not affect the tight engagement of its two sections. The sturdy construction of the tool enables it to withstand far greater stresses than the pipe with which it is used, and it will deliver the full torque capacity of the string in either direction without unscrewing, it is stated. To break the joint, however, it is only necessary to place from one to three unscrewing turns in the pipe and lower slowly until the joint breaks.

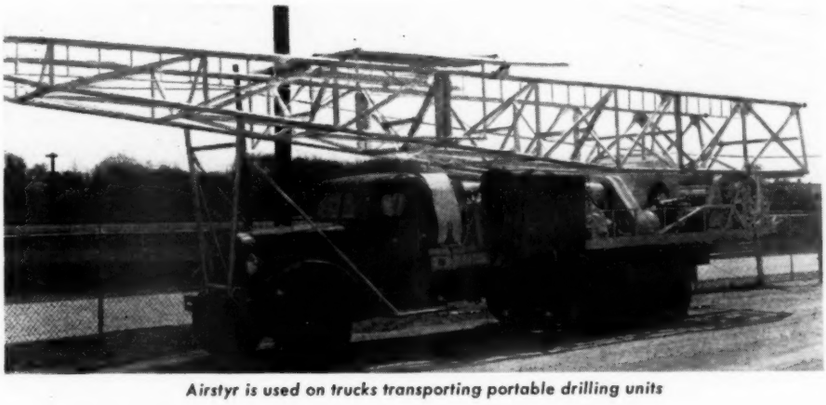
For further information, write S. R. Bowen Company, Santa Fe Springs, California.

Airstyr Power Steering

AIRSTYR, power steering by compressed air, developed and manufactured by Airstyr Company, 4704 Navigation Boulevard, Houston, Texas, has demonstrated its many outstanding advantages during the last several years, according to the company. Airstyr is a simple, effective, and safe application of power to one of the most vital points of a vehicle, the steering gear, it is stated.



Cross-section showing location of Airstyr equipment



Airstyr is used on trucks transporting portable drilling units

According to the manufacturer, trucks equipped with Airstyr are as easily steered as light passenger cars without violent or jerky action, giving drivers perfect control at all times on rough muddy roads, or where roads do not exist. In use on trucks carrying portable drilling units, Airstyr has made the trucks mobile under all conditions, it is asserted.

Operation of the Airstyr unit is by a spring loaded universal fitted with a steering wheel replacing the standard steering wheel. Operation of the power unit is accomplished by applying a slight pressure on the steering wheel when turning right or left, regardless of the steering wheel's position. The wheel is thus tilted, which operates the four-way valve transmitting power to the double-acting air cylinder. With the steering wheel in normal position, the valve is held in neutral and conventional driving used, conserving the air-pressure. A shut-off valve on the intake line to the main valve permits the air supply to be cut off at any time. The air supply is obtained from the compressor and reservoir with which trucks are now usually equipped.

Link-Belt Rubber-Tread Return Idler for Belt Conveyors

THE development and manufacture of a new line of rubber-tread idlers for supporting the return run of 14 to 60 in. wide belt conveyors, is announced by Link-Belt Company, 220 South Belmont Avenue, Indianapolis, Indiana.

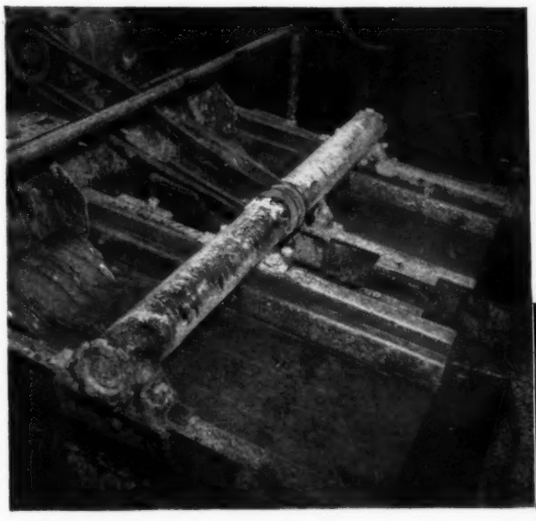
Each complete idler consists of from four to twelve 6-in. diameter rubber-tired rolls suitably spaced and mounted on a "Friction Fighter" roller-bearing-equipped steel tube that will fit into the same supporting hangers as the regular Link-Belt return idler roll.

The new idlers are especially recommended for conveyors handling corrosive, abrasive, wet, or sticky materials, because (1) there is only a rubber-to-rubber contact between return idler and the underside of conveyor belt, and (2) the kneading action of the rubber treads keeps the material from building up, also helping to break-up and loosen ice forming on the belt in freezing weather.

A copy of new Folder A-640, giving sizes, dimensions, list prices, is available to any interested reader upon request addressed to the manufacturer.

NEW FEATURES ★ NEW DESIGNING ★ NEW ECONOMIES

FOR ROTARY MUD RECONDITIONING



Here's one of numerous installations of the new dual Link-Belt NRM-124 vibrating mud screens that's seeing plenty of action these days. This latest development in Link-Belt mud screens features two 24"x48" screens mounted on skids as one unit, with one mud collecting tank and inlet chute. A single motor or turbine drives both screens. Write for Folder No. 1872-A.

LINK-BELT COMPANY
Philadelphia, Houston, Dallas, Los Angeles, New York, Toronto
Sold by most supply houses.
8547

LINK-BELT MUD SCREEN
THE VIBRATING SCREEN THAT HAS EVERYTHING

Los Angeles Nomads Hold Meeting During Foreign Trade Week

The problems involved in the selection of equipment for foreign operations were discussed by Dale Nix of the California-Arabian Standard Oil Company at the meeting of the Los Angeles Chapter of Nomads held at the Jonathan Club in Los Angeles, May 23. The regular monthly meeting of the Nomads was held over to this date in order to place it in Foreign Trade Week and several other speakers of note addressed the members and guests along lines appropriate to export business.

The first speaker of the evening was E. F. Sitterly of the Importers' Guide, New York. He discussed our present relations with South American countries and pointed out the necessity for a spirit of coöperation to be shown not only by the United States but by the various South American countries with whom we are seeking closer relations.

Following Sitterly's address, Albert W. Hill, publicity director for Foreign Trade Week and representing the Los Angeles Chamber of Commerce, told of the purpose of the Foreign Trade Week and its relation to the oil industry. The third speaker was William T. Foran of Iraq Petroleum Company who recently returned from the Near East. Foran's talk concerned the influence of Iraq and Syria on the war situation and particularly of the part that oil in that area is playing in present developments.

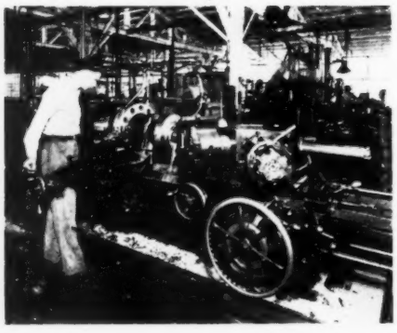
Although Nix's speech was extemporaneous, it clearly disclosed his knowledge of the problems involved in the selection of oil equipment for foreign operations as based on both experience and a careful study of the subject. He first asked the representatives of manufacturers of oil tools if the equipment they were sending to foreign fields was dependable; if it was the kind they would stake their business on. He reminded them that oil equipment purchases begin with the geologist and that the man in charge of exploratory work must know something about how he is going to get the equipment into the country, what kind of camp to build for workers, and what the casing program is going to be. He must determine to some extent the size and weight of all the equipment that will be required. "If we don't know what you have," Nix said, "we don't know what to order. We in foreign fields appreciate when you have something new to offer that has been tried out and proved, and we want you to keep us informed."

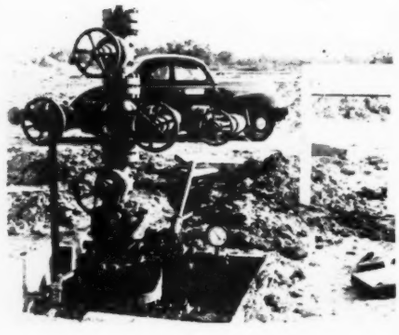
The supplier of equipment is frequently asked to recommend a list of spares. There are no supply stores near most foreign operations and the companies have to maintain storehouses of their own. Spare parts have to be on hand to run a certain piece of equipment for a certain period of time and the supplier is depended upon to make honest recommendations. If he recommends too much the operator is left with an oversupply; if he recommends too little the operator is often caught short. In general, however, Nix said that suppliers have given fair and honest recommendations.

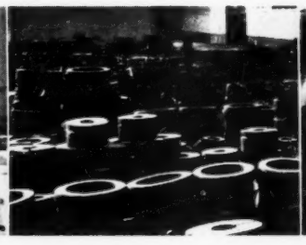
"Give some attention to packing," he continued, "for this is very important. We do not always have port facilities or means of readily transporting heavy equipment that very often has to be done by the crudest methods. Most of you do a very excellent job of packing, I know."

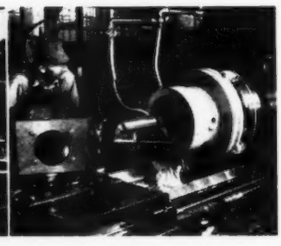
A good many pieces of equipment in this country are handled on a rental service basis and the operators and many of the crews make no attempt to learn how to use them. When these crews get out on a foreign job they must be able to operate practically each and every piece of equipment and know how to repair it. The speaker, therefore, emphasized that complete and detailed instructions are very important.

Our Experience Here ↓ means Your Safety Here ↓









DESIGN: Thirty-five years have taught us which designs work and which ones do not—which packings work and whether five or six inch slips are best for this casing hanger. This experience protects you from troublesome, poorly designed equipment.

MATERIALS: Thirty-five years have taught us which steels have the strength, shock resistance and hardness to best withstand the service encountered in the field. This experience enables us to select materials that give you maximum protection from leakage and failure.

MACHINING: Thirty-five years have taught us the type of finish and tolerances necessary for perfect performance. We *rigidly adhere to these tolerances and finishes* in every piece of equipment.

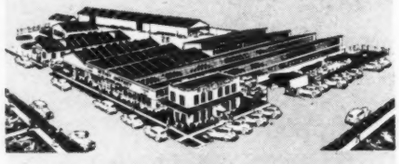
For thirty-five years we have been continuously trying to find better ways to serve you and better equipment to complete your wells.

This long experience behind every piece of McEvoy equipment is your greatest assurance of sound design, good materials and correct machining.

Order a McEvoy Christmas Tree for your next well. See for yourself how much our long experience means to you—in economy, in safety and in peace of mind.

SOLD THROUGH LEADING SUPPLY STORES EVERYWHERE

McEVOY
COMPANY
Texas at Milby St., Houston, Texas



EXPORT OFFICE
30 Church Street, New York, N. Y.

In closing, Nix summed up the requirements in three words: *Foresight, dependability, and coöperation.*

After a recess, a moving picture sponsored by the Chrysler Corporation and entitled "Wheels Across India" was shown.

Fuel and Lubricant Testing Course

A course in fuel and lubricant testing given by Texas A. and M. College as a night school course at Kilgore Texas Junior College has been approved by the Federal Government.

The objective of this course is to provide instruction in fuel and lubricant testing in strict accordance with present U. S. Government Specifications, and thereby train inspectors of motor fuels, Diesel-fuel, and lubricating oils. Most of the tests are also used by the oil companies.

The course is to be given for 12 weeks and began June 9. There is no tuition.

Qualifications for admission are two years of college engineering training with at least inorganic, qualitative, quantitative chemistry, and physics.

C. A. Lester Passes Away

CHARLES ARTHUR LESTER

Charles Arthur Lester, 47, Dallas, Texas, died May 15 after a prolonged illness. He is survived by his widow and daughter, two brothers, and a sister.

Lester had been an active independent oil operator in Texas since 1925. He first became connected with the oil business in Bartlesville, Oklahoma, in 1913. During the World War he served in the Signal Corps and for a number of years after the war was with the Marland Oil Company in Oklahoma. In 1933 he became a partner in Lester and Duffield, Inc.

Born in Columbus, Kansas, and receiving his preliminary education there and at the high school in Pawhuska, Oklahoma, he was awarded the LL.D. degree and was admitted to the bar of Oklahoma in 1923. Lester practiced law in Tulsa, Oklahoma, Cross Plains, Texas, and Cisco, Texas. He was secretary of the Dallas Petroleum Club and director and member of the executive committee of the Independent Petroleum Association of America.

Link-Belt Promotes Ewell and Woerwag

George L. Morehead, vice-president in charge of eastern operations, Link-Belt Company, announces that Laurence M. Ewell has been appointed general manager of eastern division operations, with headquarters in Philadelphia.

Ewell, who has until now been export manager, and manager of the company's New York office, will be succeeded in that position by his very able assistant, Carl A. Woerwag, with headquarters in New York as before.

L. M. EWELL C. A. WOERWAG

McKISSICK

BLOCKS

for every Purpose

SAFETY Tubing Block

SAFETY Floor Block

Coring Block

Traveling Block

Construction Block

See Composite Catalog—Page 1652 for complete description and prices

McKISSICK PRODUCTS CORP'N

EXPORT OFFICE — 149 BROADWAY, NEW YORK CITY

TULSA, OKLAHOMA

A STANDARD CHOICE

Ludlow Double-Disc Gate Valves employ the famous principle of gate and wedge construction which Ludlow developed and perfected. Valves embodying this type of construction are particularly suited to motor operation. All danger of jammed gates is eliminated because the wedges release with a minimum amount of energy. This principle also allows free operation throughout the full length of the gate travel, lessening motor wear and power consumption.

Ludlow Valves can be furnished in all standard sizes and types or specially made to your specifications. Write for catalog and prices or we shall gladly recommend and quote on valves for special purposes.

LUDLOW PRINCIPLE

Self-releasing 30° angle wedges and flexible action gates self-adjusting to seats for improved performance, longer life.

Part of a recent shipment of Ludlow Valves for a larger refinery operation.

The LUDLOW VALVE MFG·CO·INC· SINCE 1866 TROY·N·Y·

Bantam Promotions Announced

Bantam Bearings Corporation, South Bend Indiana, has announced important changes in its management, due to the resignation of A. H. Frauenthal, formerly vice-president and general manager.

R. B. Nichols, formerly secretary, has been named vice-president and general manager, and J. Frank Oehlhoffen, who has been serving in the capacity of assistant sales manager, has been moved into the position of sales manager.

R. B. NICHOLS

J. FRANK OEHLHOFFEN

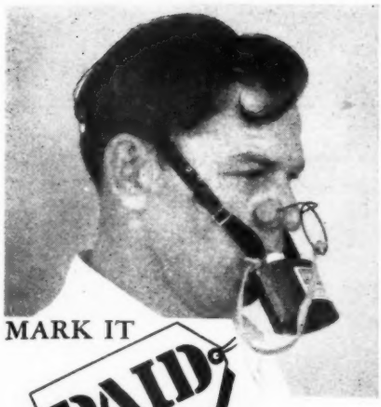
"Spud" Linder Takes Martin-Decker Service to Rocky Mountain Area

"Spud" Linder, Martin-Decker Corporation service man, recently left the company's Long Beach plant for an extended trip that is expected to take him to every active drilling rig in the Rocky Mountain territory. Linder is driving a service car equipped with the very latest and most complete portable calibrating and testing equipment for the line of Martin-Decker indicators and gauges. His service trip will probably consume several weeks in the Rocky Mountain area.

New Staynew Filter Catalog

Staynew Filter Corporation, Rochester, New York, announces the publication of a new 44-page catalog, illustrating and completely describing the latest Staynew and Protectometer Filters for compressed air, gases, liquids, engine and compressor intake, and for building ventilation. The new catalog is replete with photographic illustrations, sectional drawings, diagrams, specification charts, and detailed engineering data. It is the largest and most complete catalog ever published by the Staynew Filter Corporation, and contains a wealth of valuable information.

The new catalog is mailed, without charge, to representative firms requesting it on their business letterheads. A Staynew Filter advertisement describing models widely used in the oil industry will be found on page 110 of this issue of *The Petroleum Engineer*.



MARK IT

PAID

Every time this Canister is used

Gas concentrations are rarely "too light" to be harmless. Saving a half day layoff due to headache pays for the wearer's Bullard Refillable Canister mouthpiece Mask. Elastic headband holds mask comfortably in place. When not in use, headband holds mask slung around neck... ready for instant use. When charge is exhausted... slip in a new *inexpensive* long-life cartridge.

Ask for Bulletin 4059. E. D. Bullard Co., 275 Eighth Street, San Francisco. B-6

Everything BULLARD in Safety

Look for the Arm and Hammer

ARMSTRONG BROS.

STUB END WRENCHES

These extra heavy, ruggedly designed Chrome Vanadium Steel Wrenches take long tubular slip-over handles, stand up to long leverage... tighten screws, bolts and nuts far tighter or loosen them even when badly corroded. These are ideal wrenches around rigs, pipe lines and for general heavy duty work. Three types (from 1¼" to 3½") with long hollow tubular steel handles, each of which fits several sizes.

Write for Catalog

ARMSTRONG BROS. TOOL COMPANY

"The Tool Holder People"

331 N. Francisco Ave., Chicago, U. S. A.

Eastern Warehouse and Sales:

199 Lafayette Street New York

Merchrome Coated Valves For Mud Lines Developed By Nordstrom

REVEALING unusual performance records of Hypreseal valves in mud-line service, a bulletin featuring Nordstrom Merchrome Coated Valves has been issued by Merco Nordstrom Valve Company. Actual unretouched photos are presented of valves removed for inspection after use in drilling for long periods of time. One of the valves was used on a bleeder line for more than eight months in connection with drilling more than 100,000 ft. of hole. The surfaces of the Merchromed plug and the interior of the body show practically no wear nor any sign of channeling.

This new bulletin describes the Merchrome coating process and its application to mud-line service. Sizes are listed, 2 in., 3 in., and 4 in., with tables of specifications covering dimensions, pressure ratings, and new numbers to be given to these valves. For ready identification, all Merchrome coated valves are to be painted with bands of distinctive color at the fillet of the flanges and each valve will carry a boss plate with the letters MM on it.

The Merchrome process is an exclusive patented development whereby the plugs and interior of bodies of Nordstrom valves are hard faced to prevent corrosion and erosion.

The new Bulletin, No. V-136, gives full details. A copy may be obtained by writing to Merco Nordstrom Valve Company, 400 Lexington Avenue, Pittsburgh, Pennsylvania.

McEvoy Entertains With Barbecue

Officials of the McEvoy Company entertained many leading figures of the Houston, Texas, oil industry at the McEvoy plant, May 14. Attendance was about 150.

A barbecue lunch was served in the shops after which visitors inspected plant facilities. Of special interest to many was the section of the plant devoted to the manufacture of machine gun mounts for the U. S. army as a part of the National Defense Program.

A McEvoy intermitter gas-lift was set up for demonstration on the grounds. It attracted widespread attention and much favorable comment.

"WE WERE PERSUADED"

"We were persuaded to try the use of *Sand-Banum* boiler treatment and were pleased to learn that very active results were observed by our men who washed out the boilers.

After the second or third washout they reported that this treatment was the most effective that they had ever used. We are continuing this treatment believing it is meeting our feedwater situation admirably."

The above is quoted from a letter written in 1935. Today they still find Sand-Banum the most effective treatment available.

"The Entirely Different Boiler and Engine Treatment"

SAND-BANUM removes old and prevents new boiler scale and corrosion. Ask for details that you, too, may enjoy the same admirable results.

Test

SAND-BANUM

on our "Satisfaction or No Money" Guarantee!

AMERICAN SAND-BANUM COMPANY, Inc.

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New York City

Stocks carried by

WESTERN SAND-BANUM COMPANY
Houston, Texas Fresno, California
and at other convenient points including leading supply houses

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PETROLEUM MACHINERY CORP.
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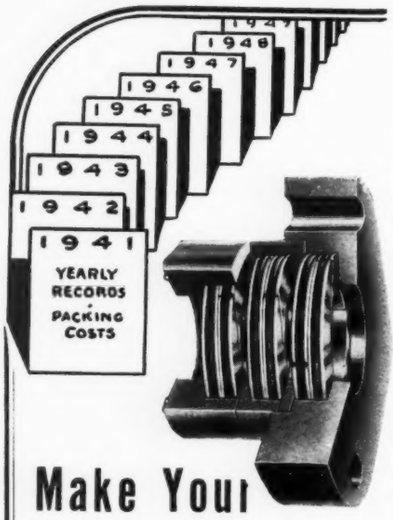


Make Your Next Packing Job *L-A-S-T!*

During these days of increased production, it is especially annoying and costly to experience shutdowns due to packing trouble.

There is a solution. Install France "Full-floating" Metal Packing in your engines, pumps and compressors. The result is increased efficiency. And each job lasts for years without maintenance expense. Saves money, too, in the long run.

Installation is a simple procedure. See that the rings are installed as lettered to correspond with similar letters on the case. As simple as A-B-C.

Sold on approval Satisfaction Guaranteed

Write for details and Catalog M-3. Make your next packing job L-A-S-T!

THE FRANCE PACKING COMPANY
Tacony Philadelphia Penna.
Mid-Continent Representative:
Mr. J. M. FULLER, 2603 Azle Avenue
FORT WORTH, TEXAS

Original FRANCE METAL PACKING

Downing Joins Lane-Wells

R. B. "Ike" Downing, well known Mid-Continent consulting geologist,

R. B. "IKE" DOWNING

recently joined Lane-Wells Company as sales engineer-geologist. He will make his headquarters in the Union National Bank Building at Wichita, Kansas.

Downing attended the Colorado School of Mines for three years and was graduated by the University of Oklahoma with a B.S. degree in 1925. After graduation he spent two years in mining work and since 1927 has been engaged in geological engineering work.

Houston Nomads Hold Annual Golf Tournament, Barbecue

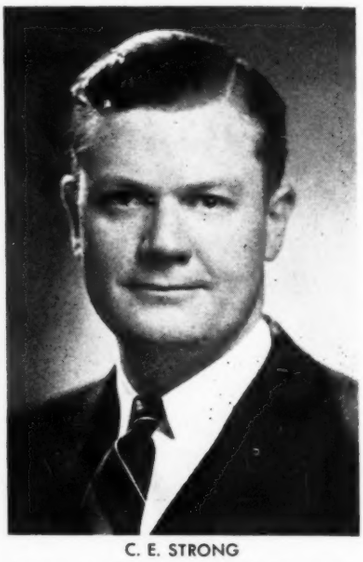
Members of the Houston Chapter of Nomads held their annual golf tournament and barbecue at the Braeburn Country Club recently, with a large number of guests participating. Tournament prizes were awarded as follows:

Duplicate prizes for the Nomad member and guest receiving the lowest gross and lowest net scores, with Gordon Richmond, Hughes Tool Company, club member who shot an 84, and Bill Flenniken, Halliburton Oil Well Cementing Company, guest, with 73, receiving the gross-score prize of one dozen golf balls, and Kenneth Craver, Thornhill-Craver Company, club member with a 74, and Burt Nasman, Continental Supply Company, guest with a 72, receiving low net prizes of umbrellas.

Sport shirts were awarded to Gus Layton, Harry Edwards Drilling Company, as the player making the most birdies; to Charles Glasscock, Wilson Supply Company, for the greatest number of sevens; to Harry Miller, The Ohio Oil Company, for the player nearest to the pin on the first shot on No. 7, and to Tom Nelson, Gulf Publishing Company, as the player nearest to the pin on No. 16.

Strong New Representative For Byron Jackson

The Oil Tool Division of Byron Jackson Company, announces the appointment of C. E. (Bud) Strong as Rocky Mountain and Canadian representative, with headquarters at Casper, Wyoming. Strong has a background of several years' activity in various fields.



C. E. STRONG

E. L. Decker on Trip

E. L. Decker, vice-president of Martin-Decker Corporation, Long Beach, California, left that city recently for an extended trip to the Gulf Coast and Mid-Continent in the interests of his company. He attended the A.P.I. Mid-year meeting at Tulsa, May 19, and received the certificate of award for the Los Angeles Chapter of Nomads.

E. L. DECKER

Elastic Stop Nut Plant Enlarged

The Elastic Stop Nut Corporation has doubled the floor space of its plant at Union, New Jersey. The original building was erected in 1940 by The Austin Company, and has attracted considerable attention by virtue of the fact that all of its steel construction is fastened with bolts and Elastic Stop Nuts instead of rivets.

Charles T. Casebeer Killed in Car Accident

Charles T. Casebeer, 37 years old, Mid-Continent Division sales manager for Lane-Wells Company with headquarters at Oklahoma City, Oklahoma, was fatally injured in a freak automobile accident in the heart of Olney, Illinois, Friday, June 6. Burial and funeral services were held in Oklahoma City.

Flown to Olney, Mrs. Casebeer was at her husband's side when he died without regaining consciousness.

Bruce R. Miller, Illinois representative of Lane-Wells, was severely injured in the accident, but is recovering satisfactorily. He is under a doctor's care at the Olney hospital.

Casebeer is a native of York, Nebraska, and graduated as a geologist from the University of Nebraska. From 1929 to February 1, 1938, he was employed by the Coline Oil Company, first at Ardmore, Oklahoma, and then at Oklahoma City. He had been with Lane-Wells Company since 1938.

W. T. Foran Addresses Southern California Section A.I.M.E.

An address on the geology of the Near East with particular reference to oil was the highlight of the dinner meeting held by the Southern California Section of the A.I.M.E. in Los Angeles recently. This talk was given by William T. Foran who recently returned from Iraq where he has done considerable geological work since 1936. Foran illustrated his talk with maps and cross-sectional drawings and gave the structural history of Iraq in drawing his conclusions regarding the saturation of reservoirs throughout the country. The meeting was one of the most interesting ever held by the Southern California Section of the A.I.M.E. and members stayed long after the talk was completed in order to discuss the points brought out by the speaker and examine the formation samples he had with him.

Immediately following the dinner, moving pictures in color taken by J. Terry Duce of the California Arabian Oil Company were shown. These pictures depicted scenes taken along the route from New York, through Egypt, in the Near East, and in India. Foran described the pictures as they were shown.

New Ohio Distributor for Bucyrus-Erie Spudders

The Zanesville Tool and Supply Company of Zanesville, Ohio, have recently been appointed as distributors for the sale of Bucyrus-Erie oil-well spudders in the State of Ohio. This firm maintains an office and warehouse at Zanesville, with resident salesmen at Marietta, Newark, and Wooster. B. R. Straker is president of the firm and handles the northern Ohio territory.

The new Bucyrus-Erie 36-L and 24-L spudders will be featured by the Zanesville firm.

COFFING *"Safety-Pull"* HOISTS
For every lifting and pulling job

Today's demand on every industry requires that all plants be equipped with time and labor saving maintenance and production equipment. Coffing "Safety-Pull" ratchet lever hoists are especially designed for all types of construction and maintenance work. Wherever a lift or pull is needed the "Safety-Pull" will do the job safely, quickly and economically.

SPUR GEAR
Chain Hoists

Coffing builds two types of Spur Gear chain hoists. The regular Model YC and the Cam Actuated Model "C" two-gear hoist. These hoists are guaranteed against defective material and workmanship. Coffing Spur Gear hoists have a number of outstanding features and are factory tested at 100% over their rated capacity. Built in capacities from ½ to 4 tons, weighing only 75 to 120 pounds.

Coffing Hoist Co.
Ratchet Lever, Spur Gear and Electric Hoists
Danville, Illinois

WHAT METHOD SAVES TIME AND EFFORT IN CLEANING FLOORS?

As many oil companies the Nation over will tell you, the RIGHT ANSWER for cleaning refinery, barrel house, bulk or pumping station floors is the fast, inexpensive Oakite way!

Simply make up solution of Oakite Penetrant, allow short soak and brush with stiff fibre brush. Then rinse with pressure hose or mop up . . . and you will find oil, grease and dirt deposits are completely, speedily removed, leaving your floors in the clean, film-free condition you want! Slipping hazards are eliminated . . . fire hazards avoided. Details on request. Write today.

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Representatives in all Principal Cities of the U. S. and Canada

OAKITE *Certified* CLEANING
MATERIALS & METHODS FOR EVERY CLEANING REQUIREMENT

See our ad in "Composite Catalog," or write for literature. Buy from your supply store.

● Every part of this famous tool is built to bear its share of the load. Chains are individually *proof-tested and certified*. Jaws and Handle are tough drop-forgings. Through-bolt is extra heavy, and its U. S. Standard Nut simplifies replacement. 8 sizes, either Flat or Cable Chain, for pipe 1/8" to 18".

Also "VULCAN BOLL-WEEVIL"

A *reversible action* tong for flat pipe work—very efficient in trenches. Changes instantly from "making-up" to "breaking-out" without even unhooking chain. Jaws reversible for double life. Chains *proof-tested* and *certified*. 4 sizes, 3/4" to 12" pipe.

J. H. WILLIAMS & COMPANY, 225 Lafayette Street, NEW YORK

Larkin Packer Rearranges Sales Territories

Larkin Packer Company, Inc., announces a rearrangement of sales territories.

The Northern Division, under the supervision of H. S. Lindenmuth, now comprises an area including Illinois, Indiana, Kansas, Nebraska, and Oklahoma. Lindenmuth will maintain headquarters in Tulsa, Oklahoma. Prior to his recent appointment as manager of the Northern Division, he served as city salesman in Tulsa, and previously covered the Kansas territory for Larkin.

H. S. LINDENMUTH

The Western Division now includes the Panhandle of Texas, North Texas, West Texas, and New Mexico, and is under the supervision of W. H. Adamson, who will maintain headquarters in Odessa, Texas. Adamson was district manager for the Northern Division, prior to his appointment in West Texas, and previous to that time he worked the West Texas territory for Larkin.

The Southern Division now includes East Texas, Louisiana, Arkansas, Mississippi, the Gulf Coast, and Southwest Texas. Tom E. Alexander, manager of this division, makes his headquarters in Houston, Texas.

Coincidental with the division changes, Larkin appointed H. H. Francis to work the Kansas territory. He replaces Ed Wallace, who was recently called to military service. Francis will make headquarters in Great Bend, Kansas.

Jack Hancock, a resident of Wichita Falls, Texas, will work the North Texas territory, succeeding H. A. Ferguson. Hancock will continue to maintain headquarters in Wichita Falls.

H. J. Stewart, who recently joined the Larkin sales force after a number of years in the engineering department of a major oil company, will work in Houston and the surrounding territory.

A. W. Parker Retires From Worthington

After 54 years of continuous service, A. W. Parker is this month retiring from active service with the Worthington Pump and Machinery Corporation.

Well known in industrial advertising and engineering circles, Parker entered the field in 1887, beginning as a draftsman. Through many years he served as mechanical engineer and product designer and contributed importantly to the development of a variety of pumping machinery. Later, he entered the publicity function, in which he was engaged until his retirement.

John Zink Announces Dallas Branch

C. E. MORRIS

The John Zink Company, of 4401 South Peoria, Tulsa, Oklahoma, announces the appointment of C. E. Morris as manager of its Dallas branch, located at 2405 South Harwood. Morris has a wide acquaintance in Texas, being a Texan and a graduate of the University of Texas.

This new branch will carry a wide assortment of John Zink floor furnaces, unit heaters, and industrial burners, as well as all types of oil production and refinery burners.

M. R. Dill Elected Director Lincoln Electric

The Lincoln Electric Company, manufacturers of arc-welding equipment, Cleveland, Ohio, announced the election of M. R. Dill as a director at its recent annual meeting of shareholders. Dill was also elected general counsel at the last meeting of the board of directors.

M. R. DILL

Dill graduated from Lakewood High School in 1925, and attended the Wharton School of the University of Pennsylvania for his pre-law education. He graduated from the Law School of Ohio State University in 1930 and immediately became associated with the well-known law firm of Squire, Sanders and Dempsey, Cleveland, Ohio. During his college career he took an active part in athletics, was on the varsity football team, and was a member of Sigma Chi and Phi Delta Phi legal fraternity. Dill is vice-president of the National Alumni Association of Ohio State University and a member of the Hermit Club of Cleveland.

Directors and officers who were reelected include: J. C. Lincoln, chairman of the board of directors; J. F. Lincoln, president and general manager; C. M. Taylor, vice-president; A. F. Davis, vice-president and secretary; G. G. Landis, chief engineer; Harold F. Kneen, plant superintendent; J. W. Meriam and W. B. Stewart, directors.

Mid-Continent Representative

Gray I. Thomas has recently been appointed Mid-Continent representative for Rains Wood-Metal Packings. Headquarters of the company are at 904 Broadway, Spokane, Washington. A. E. Rains is president of the company.

General Electric Advances Two Men

J. M. Howell, executive assistant to E. D. Spicer, manager of the Schenectady Works of the General Electric Company, has been named to succeed his chief who has been advanced to the post of assistant to the vice-president in charge of manufacturing. Official announcement of the promotions was made by W. R. Burrows, vice-president in charge of manufacturing.

Lee Kinnebrew Dies From Heart Attack

Lee Kinnebrew, 61, Shreveport, Louisiana, died June 2 of a heart attack. Kinnebrew was one of the outstanding independent oil operators and drillers in Louisiana, Texas, and the entire Southwest. He had been in ill health with heart trouble for about two years.

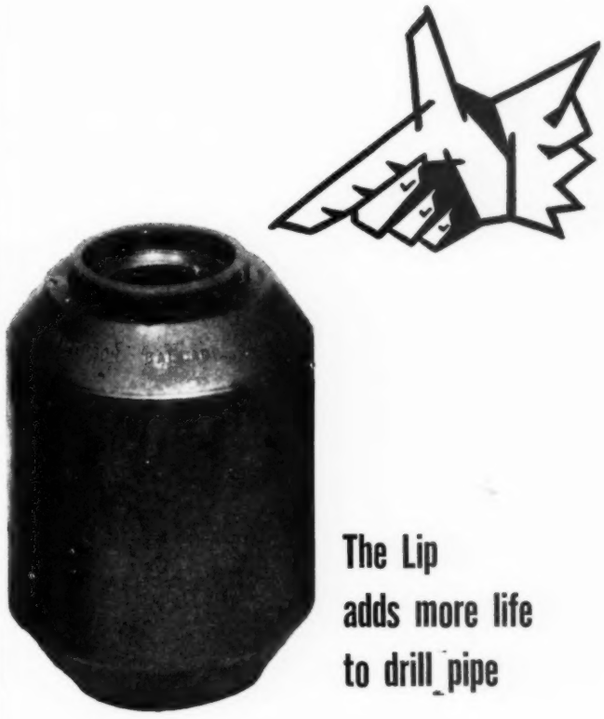
Funeral services were held at First Baptist Church, Shreveport, and interment was in Forest Park Cemetery.

Kinnebrew is survived by his widow, two daughters, one son, three brothers, and two sisters.

Kinnebrew entered the oil business in 1898. Besides his activities in the oil industry, he was also president of the Louisiana Refrigerated Products Corporation, Inc. A recognized authority on drilling, he was widely known for his achievements in the petroleum industry.

PATTERSON-BALLAGH

LIP PROTECTORS



The Lip adds more life to drill pipe

It's amazing the way this simple improvement increases drill pipe life. By adding lips to Patterson-Ballagh Protectors, "ringing" or grooving of pipe is eliminated. The lips at top and bottom add approximately 15% more contact with the pipe. This assures an even tighter grip on the pipe. They help streamline the string, prevent eddy currents in the corners and prevent settling of the mud around the upper edge. This is an exclusive improvement offered only by Patterson-Ballagh. Ask for more details.

PATTERSON-BALLAGH
Corporation

Los Angeles Houston New York City

THE MODERN BOLT DIE STOCK

Adjustable for deep or shallow threads. Segmental dies are easily resharpened or replaced at low cost. Compact and easy cutting. Any combination can be furnished. Adjustment is simple. A part turn of knurled sizing ring adjusts dies to deep or shallow as desired. Each die segment does an equal share of the work.

Two models — No. 101 capacity ¼" to ⅝". No. 102 capacity ½" to 1". N.C. or N.F. thread. Write for complete details.

THE TOLEDO PIPE THREADING MACHINE COMPANY
TOLEDO, OHIO *New York Office, 502 No. 2 Rector Street Bldg.*

"TOLEDO"
TRADE-MARK REGISTERED U.S. PAT. OFFICE

The **MEN** behind **UNION WIRE ROPE**

Every Union Wire Rope man is *trained* for his job. In the plant, in the engineering department, on the sales force you will find only competent men — men whose natural ability has been enhanced by a thorough and rigid course of training. Union Wire Rope men take pride in the products they sell — pride in delivering complete satisfaction to the customer.

UNION WIRE ROPE CORPORATION
2106 Manchester Ave. Kansas City, Mo.
Tulsa • Houston • Chicago • Salt Lake City
New Orleans • Monahans • Portland • Ashland, Ky.

UNION *Wire Ropes*

The "ULTIMATE LOW COST WIRE ROPE"

Frank E. Richardson Joins Pan American

Frank E. Richardson, until recently chief engineer of the Great Lakes Pipe Line Company in Kansas City, Missouri, has resigned that position and joined the Pan American Companies in Houston, Texas, as manager of the Pan American Pipe Line Company, and assistant manager of Pan American Production Company and Pan American Gas Company. In these capacities he will function as operating and administrative assistant to E. R. Turner, vice-president of the three companies.

FRANK E. RICHARDSON

Richardson was born in Mahanoy City, Pennsylvania, and was educated for mining engineering at Ohio Wesleyan University. After graduation, he spent four years as a consulting engineer at Clarksburg, West Virginia, doing mining, municipal, and oil-field engineering. From 1916 to 1922, he designed and constructed gasoline plants throughout the Mid-Continent area, and from 1922 to 1923 was assistant superintendent and designing engineer on the construction of the Spavinaw Dam in northeastern Oklahoma, which was built for the purpose of supplying the City of Tulsa with a municipal water supply. After the completion of this work, he went to Wyoming and was general superintendent of construction and operation of the refinery and town of Parco, Wyoming. From 1926 to 1929, he was chief engineer for the Marland Oil Company and Continental Oil Company in Texas and Oklahoma, devoting his main efforts toward design, installation, and operating efficiency of plants and equipment having to do with the production of crude oil and gas.

When the Great Lakes Pipe Line Company was organized for the purpose of constructing their gasoline lines from Oklahoma to the north central states, he joined that company as chief engineer for design, construction, and operation of the system, and since that time has served as chief engineer.

Richardson is a member of the American Society of Civil Engineers and Sigma Alpha Epsilon Fraternity. He is married and he and Mrs. Richardson will make their home in Houston.

Kalton and Thomas Advanced by Chain Belt

Chain Belt Company of Milwaukee, Wisconsin, announces the appointment of D. A. Kalton and A. W. Thomas as assistants to the sales manager of the Construction Equipment Division of the company.

Kalton has been with Chain Belt Company since graduation from Marquette University in 1932 and has served both in the home office sales department and as eastern district manager.

Thomas who is also a former district manager has been connected with the company since 1927. He has been connected with both the sales and engineering departments of the Construction Equipment Division and is a graduate of Purdue University in civil engineering.

Crane Co. Elects V. P. Rumely Vice-President

Crane Co., Chicago, Illinois, announces the election of V. P. Rumley as vice-president in charge of manufacturing, to succeed J. H. Collier who was made president recently. Rumely has been works manager of the Crane Chicago plant for the last four years, during which he has been very closely associated with Collier.

V. P. RUMELY

Born 52 years ago in La Porte County, Indiana, Rumely studied mechanical engineering at Purdue University, and later at the University of Wisconsin, graduating in 1912. His first job after leaving college was in the farm implement plant of his grandfather, M. Rumely, in La Porte, Indiana. (Later known as the Advance Rumely Company.) In 1914-15 he was with the Buick Motor Company, and in 1916 went to the Hudson Motor Company. Beginning in the Hudson shops, he progressed through every stage of production management to superintendent and factory manager, the position he held when he resigned to join the Crane organization in 1937.

San Joaquin Valley Chapter A.P.I. Holds Interesting Meeting

A regular meeting of the San Joaquin Valley Chapter of the American Petroleum Institute was held at the Standard 11-C Meeting Hall, Taft, California, May 20.

Chairman Elmo Fullmer called the meeting to order with approximately 200 members and guests present.

The following appointments were announced: J. C. Rector, Union Oil Company of California, Bakersfield, to the advisory committee (term expires 1942); M. L. Barlow, Taft Junior College, assistant secretary.

Chairman Fullmer read a letter of resignation from J. B. Wells, a permanent member of the advisory committee, who has been inactive for more than a year due to serious illness. Fullmer stated that the executive board had refused Wells' resignation and had instructed the secretary to place Wells on the inactive list until his hoped for early recovery.

F. E. Abbott, Tide Water Associated Oil Company, Bakersfield, read a paper on "Test Data on Sucker Rod Pumping in Deep Wells."

P. E. Saurenman, Tide Water Associated Oil Company, Bakersfield, read a paper on "Large Volume Pumping—Kern River Field."

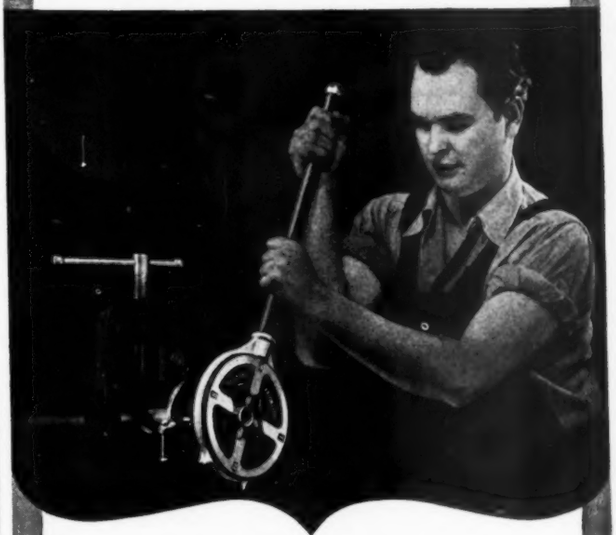
"Mutual Dependence of the Air Corps and Petroleum Industry" was the subject of a talk by Major J. F. Wadman, Air Corps, U. S. Army.

Don Lucas, independent oil operator, Bakersfield, gave an informal talk, accompanied by movies, on "Hunting in Western States."

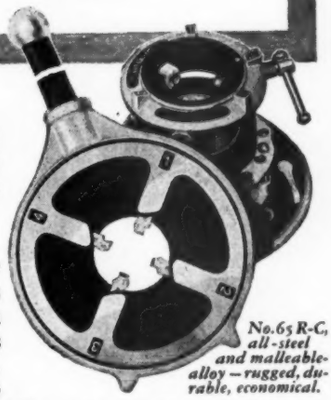
Chairman Fullmer called attention to a scheduled meeting of the A.P.I. Vocational Guidance Committee at the Taft High School and Junior College.

Following adjournment, refreshments were served under the direction of Chapter Stewards Dick Bruce and Chuck Williams.

Faster-working tools reduce strain on your men



These Work-Saver RIDGID Pipe Threaders help you "Deliver ahead of schedule.."



No. 65 R-C, all-steel and malleable-alloy—rugged, durable, economical.

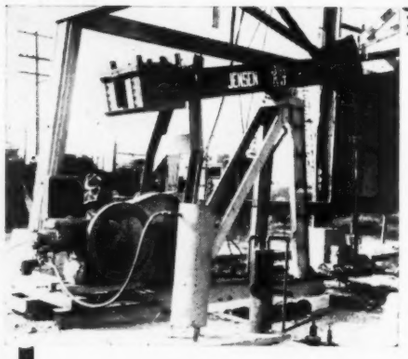
Speedy Self-contained No. 65Rs Thread 4 Sizes of Pipe with 1 set of chasers . . .

Most jobs can't wait for slow old-fashioned tools these days. Give your men these fast efficient RIDGIDs and they produce more—with less effort. . . . In 10 seconds you can set the 65R to thread 1", 1¼", 1½" or 2" pipe—no extra dies to fool with, carry around or lose. Workholders are quick, practically automatic, foolproof—set instantly to pipe size, tighten only 1 screw. Clean perfect threads from hi-speed steel chaser dies. Speed your work with these modern time and money savers—ask your Supply House for RIDGID 65Rs, today!

The Ridge Tool Company, Elyria, Ohio

RIDGID

WORK-SAVING PIPE TOOLS



14D JENSEN JACK handling a 3200-ft. well in California with seventeen 38" strokes per minute. This smooth performance of a JENSEN Unit is a beautiful thing to the man who pays the bills.

A BEACON IN A FOG

When any producer gets in a fog of claims and counter-claims about pumping equipment, there is always this important fact shining through like a beacon:

JENSEN Pumping Units are made by the oldest and largest organization in the world engaged solely in the manufacture of pumping equipment. Successful producers have been our advisory staff for 22 years.

JENSEN

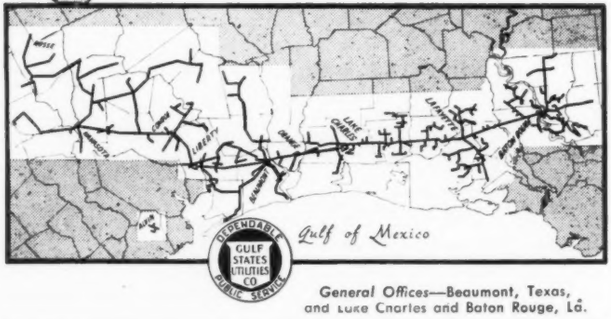
BROTHERS MANUFACTURING CO.
Coffeyville, Kansas

For detailed JENSEN JACK description and specifications, see . . . **PRODUCING EQUIPMENT DIRECTORY** or **COMPOSITE CATALOG.**

EXPORT OFFICE: 50 CHURCH STREET, NEW YORK CITY

"OIL RIGHT . . .

We're Ready!"



General Offices—Beaumont, Texas, and Lake Charles and Baton Rouge, La.

TRADE LITERATURE

What to Write For

BANTAM BEARINGS CORPORATION, South Bend, Indiana, announces Bulletin P-104 containing complete information on the compact anti-friction bearing. The corporation manufactures straight roller, tapered roller, needle, and ball bearings.

BULLETIN 4059, of E. D. Bullard Company, 275 Eighth Street, San Francisco, California, describes in detail the Bullard refillable canister mouthpiece mask. The bulletin will be sent upon request.

A NEW CATALOG, available upon request, has been prepared by The Chaplin-Fulton Manufacturing Company, 28-40 Penn Avenue, Pittsburgh, Pennsylvania, on their Fulton Spring-Type Regulator for high pressures.

METAL PACKING for engines, pumps, and compressors is described by The France Packing Company, Philadelphia, Pennsylvania, in Catalog M-3, sent upon request.

WRITE GRAY TOOL COMPANY, Houston, Texas, for a complete description of Gray fishing tools. Literature will be sent upon request.

JOHNS-MANVILLE, 22 East 40th Street, New York, New York, has prepared brochure FM-10A on J-M 420 Rotary Lining to be sent upon request.

For your copy of the KEROTEST CATALOG 41 describing complete well control systems together with Kerotest valves and fittings, address Kerotest Manufacturing Company, Pittsburgh, Pennsylvania.

LANE-WELLS COMPANY, 5610 South Soto Street, Los Angeles, California, is offering free upon request complete information concerning oil-well surveys and their applications in their bulletin "Oil Well Surveys: Their Necessity and Application."

FULL DESCRIPTION, specifications, and prices on the Larkin casing centralizers may be had by writing Larkin Packer Company, Inc., St. Louis, Missouri. The information is contained in the Larkin Catalog.

TO OBTAIN complete information on the Le Roi heavy-duty, V-type, overhead-valve engine, also the Le Roi 4-, 6-, and 8-cylinder drilling engines, address Le Roi Company, Milwaukee, Wisconsin, or Tulsa, Oklahoma, and ask for a copy of Bulletin DE4.P4.

WRITE FOR DATA BOOK NO. 1775 on Link-Belt Friction Fighter Bearings. Address Link-Belt Company, Indianapolis, Indiana, or the nearest branch office of the company. The latest development in the Link-Belt mud screen is contained in Folder No. 1872-A, sent upon request by Link-Belt Company, Philadelphia, Pennsylvania, or the nearest branch office.

LUDLOW VALVE MANUFACTURING COMPANY, INC., Troy, New York, will send upon request a catalog on the Ludlow Double-Disc Gate Valves.

A DESCRIPTION of "King-Clip" gate valves is offered by The Lunkenheimer Company, Cincinnati, Ohio, in Catalog 78. The catalog is available upon request.

THE NATIONAL SUPPLY COMPANY, Toledo, Ohio, has issued Descriptive Bulletin No. 297 on new developments in rotary swivels for deep drilling.

Complete information on National Tube Company's "COMPLETE TUBE SERVICE," which includes still tubes, condenser tubes, heat-exchanger tubes, and refinery piping, may be obtained by writing the National Tube Company, Pittsburgh, Pennsylvania,

E. M. SMITH COMPANY, 600-650 South Clarence Street, Los Angeles, California, is issuing Bulletin No. 22-OF on the new Grizzly "Hug-Tite" drill pipe bearing-protector.

A NEW 44-PAGE CATALOG containing valuable engineering data, charts, and specifications is being issued by Staynew Filter Corporation, 2 Leighton Avenue, Rochester, New York. The catalog also contains complete details of Staynew and Protectometer engine and equipment-saving filters. Description of the entire line includes filters for building ventilation.

COPIES OF A NEW BULLETIN covering a new type of mechanical seal for centrifugal or rotary pumps, agitators, and for service wherever the sealing of high volatile, gritty, or corrosive liquids is important may be had from the Durametallic Corporation, 2104 Factory Street, Kalamazoo, Michigan.

BULLETIN NO. T-412 will be mailed without charge by Reed Roller Bit Company, P. O. Box 2119, Houston, Texas, describing the new Reed Super-Shrink Grip tool joints.

THE PLOMB TOOL COMPANY, 2209 Santa Fe Avenue, Los Angeles, California, manufacturers of forged hand tools, is sending out the latest edition of its annual public relations statement to stockholders, bondholders, employees, and friends of the company.

ALLIS-CHALMERS MANUFACTURING COMPANY, Milwaukee, Wisconsin, has issued a new comprehensive 40-page bulletin, B-6146, for every pumping service requiring a high-grade single-stage, double-suction centrifugal pump. The well-illustrated bulletin is available without cost; write on company letterhead.

NOW READY FOR DISTRIBUTION are six new bulletins describing in detail various sizes of Axelson heavy-duty 24-speed geared head lathes. Copies may be obtained by writing the Axelson Manufacturing Company, Box 98, Vernon Station, Los Angeles, California, Department A.

FIVE NEW CIRCULARS, each 16 pages and in two colors, have been issued by LaPlant-Choate Manufacturing Company, Inc., Cedar Rapids, Iowa, on several of their products, the Hydraulic Trailbuilder, Hydraulic Bulldozer, and Forced Ejection "Carrimor" Scrapers. The circulars will be mailed without cost upon request.

Lord Cadman Dies

Lord Cadman died at the age of 63 in London, England, May 31. He was chairman of Anglo-Iranian Oil Company, Ltd., and Iraq Petroleum Company, Ltd. Lord Cadman was also a director of the Suez Canal Company and the Great Western Railroad. A frequent visitor to the United States in the late 1920's and early 1930's, Lord Cadman was actively interested in affairs of the American Petroleum Institute and in the American petroleum industry.

Rockford Clutches

OK'd by Oil Men

Extensive use in leading tractors, power units and specialized equipment demonstrates the approval of oil men for Rockford Clutches. You find them on the job everywhere, in all services, giving reliable control and long life under the toughest conditions.

The winch tractor shown above has a Rockford Over-Center Clutch which locks in or out of engagement with extremely powerful easy action. Rockford Spring-Loaded Clutches provide equal reliability where automobile-type control is indicated. These clutches are available in a complete range of standard sizes; and in Rockford Power Take-Offs for S.A.E. flywheel housings.

Specify Rockford Clutches on new equipment and assure lasting peak performance, all-around savings. Information on request. Experienced engineering service for developing applications is offered free to equipment builders.

Rockford Drilling Machine Division *Borg-Warner Corporation*

▼ 1303 Eighteenth Avenue, Rockford, Illinois, U. S. A. ▼

Over-Center, Spring-Loaded and Pullmore Clutches

SAFEGUARDING PRESSURE

FULTON SPRING-TYPE REGULATOR

The regulator here shown is preferable in remote, out-of-the-way places, to one of the lever type, as it protects itself against tampering or injury by weather. Its compact, light-weight design reduces handling and installation costs. Equipped for high pressure, it reduces from 300 pounds to any desired pressure between 10 and 50 pounds. For low pressure, reduces from a maximum of 50 lbs. to any outlet pressure between 4 ounces minimum and 10 lbs. maximum.

New catalog on request

The **CHAPLIN-FULTON MFG. CO.**

28-40 PENN AVE. CF PITTSBURGH, PA.

IT'S A HIT! Mounting orders for improved DURA PLASTIC Packing prove it has the stuff! Better sealing . . . greater resilience . . . uniform density. Available in bulk, coils or rings.

DURAMETALLIC CORPORATION
The PERFECT SEAL
KALAMAZOO MICHIGAN

The Petroleum Engineer

●

is available through subscription only—it is not for sale on the news stands.

●

Book Reviews

Air and Gas Compression, by Thomas T. Gill. Published by John Wiley and Sons, Inc., New York, New York. 181 pp. Price $3.00.

A new textbook on the theory of compression prompted by the recent researches in the properties of gases in regard to compressibility, critical data, and specific heats.

Included in the book is a chapter on the flow of gas in pipe lines based on the Weymouth equation with a new series of tables reducing the labor required in computing pressure drop in pipe lines.

Also, a chapter on the orifice meter, serving as an introduction to the subject, contains enough information to enable the reader to use gas handbooks published by the meter manufacturers and technical societies.

The author bases problem solution on equations, tables, and alignment charts to enable the reader to check many of his calculations in any of several ways.

●

Instrumentation and Automatic Control in the Oil Refining Company, by R. B. Werey. Published by The Brown Instrument Company, Philadelphia, Pennsylvania. 182 pp., 79 illus. Available by addressing request on company letterhead.

The author has made a complete and detailed compilation of the instruments and control apparatus used in the modern refinery for indicating, recording, and controlling the functions of temperature, flow, pressure, and liquid level.

The objective of the author is to make available to the potential user, literature in which the fundamentals of instrumentation have been treated in a form specifically covering an industry. He has written in simple language the basic considerations involved in good industrial instrumentation using illustrations and examples taken from current refinery practice, although applicable to other phases of the chemical industries. The text is a reference and guide in the coördination of the theory and practice of refinery instrumentation.

●

The Petroleum Industry: An Economic Survey, by Ronald B. Shuman. Published by University of Oklahoma Press, Norman, Oklahoma. 297 pp., 62 pp. illus., charts. Price $3.00.

This book has been designed as a trade publication for the intelligent layman as well as the investor, business man, and members of the petroleum industry in both the managerial and physical branches.

Timely because of its implication to the country's defense, and because of its international aspects, the author, from the records of various petroleum companies, has undertaken to write a description of the character of an industry whose problems of overproduction have reached national controversy regarding federal control. He has endeavored to present in unbiased manner the arguments of all factions.

●

O. N. Lindahl to Carnegie-Illinois Steel

Carnegie-Illinois Steel Corporation has announced the election of Oscar N. Lindahl as vice-president in charge of finance, succeeding M. D. Howell, who will devote all of his time to duties as vice-president—financial, secretary and treasurer of United States Steel Corporation of Delaware. Lindahl has been associated with the Universal Atlas Cement Company since 1911, more recently as comptroller and secretary.

MEETINGS

Pennsylvania Grade Crude Oil Association, Annual Meeting—June 19 and 20, Bradford, Pennsylvania.

Kentucky Oil and Gas Association, Mid-Year Meeting—June 20 and 21, Lexington, Kentucky.

Little International Oil Show—June 21 and 22, Odessa, Texas.

American Society for Testing Materials—June 23, 24, 25, 26, and 27, 44th Annual Meeting, Palmer House, Chicago, Illinois.

California Natural Gasoline Association, Monthly Meeting — July 3, Barker Bros. Auditorium, 818 West Seventh Street, Los Angeles, California.

American Chemical Society—September 8, 9, 10, 11, and 12, Atlantic City, New Jersey.

National Petroleum Association, Annual Meeting — September 17, 18, and 19, Hotel Traymore, Atlantic City, New Jersey.

National Lubricating Grease Institute, Annual Meeting—September 29 and 30, Stevens Hotel, Chicago, Illinois.

Texas Mid-Continent Oil and Gas Association, Annual Meeting—October 9, 10, and 11, Beaumont, Texas.

American Institute of Mining and Metallurgical Engineers, Petroleum Division—October 16, 17, and 18, Dallas, Texas.

Independent Petroleum Association of America, Twelfth Annual Meeting —October 20, 21, and 22, Tulsa, Oklahoma.

American Institute of Mining and Metallurgical Engineers, Petroleum Division—October 30 and 31, Los Angeles, California.

California Natural Gasoline Association—October 31, Los Angeles, California.

American Petroleum Institute, 22nd Annual Meeting—November 3, 4, 5, 6, and 7, San Francisco, California.

American Association of Petroleum Geologists—November 6 and 7, Los Angeles, California.

New Mexico Oil and Gas Association—December 3, Artesia, New Mexico.

American Institute of Electrical Engineers, Southeastern District—December, 3, 4, and 5, New Orleans, Louisiana.

National Petroleum Association, 39th Semi-Annual Meeting—April 16 and 17, 1942, Hotel Cleveland, Cleveland, Ohio.

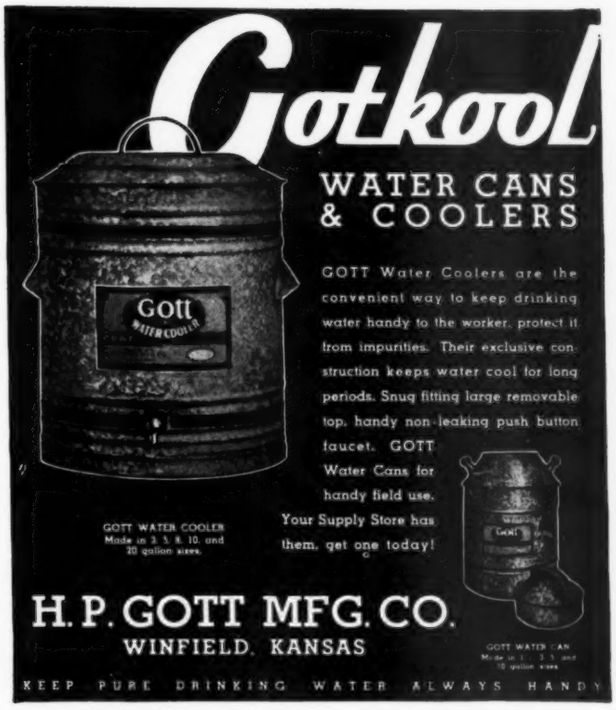
International Petroleum Exposition—May 16, 17, 18, 19, 20, 21, 22, and 23, 1942, Tulsa, Oklahoma.

Universal Atlas Cement Announces Appointments

Blaine S. Smith, president Universal Atlas Cement Company, a United States Steel Corporation subsidiary, announces the appointment, effective June 1, of Henry C. Schmielau as general auditor, and John J. Heffernan as secretary, succeeding O. N. Lindahl, comptroller and secretary, who, after more than 30 years with the company, has resigned to become vice president-finance, Carnegie-Illinois Steel Corporation, Pittsburgh.

Schmielau was born in Brooklyn, where he attended public day and evening schools. He began work as a boy with the Chase National Bank, and in 1911 joined the Universal Atlas company where he served successively as clerk, bookkeeper, assistant secretary, and assistant treasurer.

Heffernan was born in New York City, and attended public day and evening schools in New York and New Jersey. After service with the A.E.F. in France and Belgium, he worked successively in the office of the village attorney of Ridgefield Park, New Jersey; in the advertising department of the General Cigar Company, New York, and for an advertising agency in Boston. He joined the Universal Atlas organization in 1925 in the office of the secretary and treasurer, and was appointed assistant secretary in 1937.


Gotkool
WATER CANS & COOLERS
GOTT Water Coolers are the convenient way to keep drinking water handy to the worker, protect it from impurities. Their exclusive construction keeps water cool for long periods. Snug fitting large removable top, handy non-leaking push button faucet. GOTT Water Cans for handy field use. Your Supply Store has them, get one today!
GOTT WATER COOLER
Made in 3, 5, 8, 10, and 20 gallon sizes.
H. P. GOTT MFG. CO.
WINFIELD, KANSAS
KEEP PURE DRINKING WATER ALWAYS HANDY

A Complete Instrument Service

CONSULTING
CONSTRUCTION
MAINTENANCE

INSTRUMENTS INCORPORATED
A Service Organization
DALLAS

THE NUT *that is helping to keep hard-working oil field equipment on the job . . .*

Available at supply houses . . . backed by factory stocks in Houston and Los Angeles

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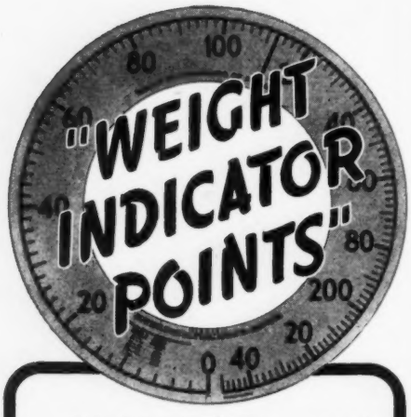

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